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The Engineer as a Department Head

SOME weeks since, I sent out a series of letters seeking information as to how *Power* could better serve its readers. Here is one of the replies that were brought out:

"One of the biggest services that *Power* could render is to stiffen the backbone of the chief engineer. The producer of any power plant product rarely finds his work difficult in interesting the chief engineer, provided, of course, the product has real merit and an application to the plant in question. However, we must often depend upon the chief engineer in turn selling our product to the management, and we regret to say that it has been our experience that the chief engineer is a most deplorable salesman.

"The chief engineer is all too apt to prefer the least possible contact with the management, perhaps with the mistaken idea that the management values him in inverse proportion to the extent of this contact.

"Now, it is our belief that if the chief engineer, as a type, is ever to get anywhere, he must establish himself as the head of a very important and a very complicated department. With this in mind he should emulate the attitude of the better class of department heads more directly concerned with production. A real department head knows that his value is directly proportional to the efficiency with which he runs his department, and he is, therefore, ever alert for any worth-while improvement in operation and ever ready to get to the management and almost demand that improvement on the strength of the economy that could be effected.

"Do we find the management disgruntled with such a department head? On the contrary, if the department head does not display a keen and aggressive interest such as this, he is soon regarded as dead timber.

"Why, then, should not the engineer come out of his shell, forget his timidity, tell the boss a thing or two about his job and how there is a great deal more to steam generation than the mere burning of coal.

"The motive behind this letter might be considered selfish, but we think there is a certain measure of altruism in it since we are confident that the results of such action as we have outlined will redound with great advantage to the engineer."

This letter brings out so well what I I have tried, myself, to say so many times that I cede my page to it this week, commending it to the thoughtful consideration of my readers.

F. R. Low

Power Plant of the Harvard Medical School, Boston, Mass.

BY CHARLES L. HUBBARD*

A CENTRALLY located plant supplying light, heat, and other services to a group of thirty-five buildings having a total space of 13,000,000 cu.ft. The equipment includes eight 3,000-sq.ft. Stirling boilers, four of which are oil-burning, three direct-current units with a total capacity of 725 kw. and several auxiliaries.

THE power plant of the Harvard Medical School, at Boston, Mass., has been in operation since 1906. It has been enlarged and the equipment added to from time to time, owing to the erection of new buildings, until now the boiler plant has twice its original capacity, and other apparatus has been supplied to meet the growing requirements and maintain the proper balance. The buildings supplied from this plant are thirty-five in number with an approximate total of 13,000,000 cu.ft. of space supplied with heat and light, in addition to which several of the buildings are furnished with power, service steam, hot water, refrigeration and compressed-air service.

A general view of the engine room is shown in Fig. 1. The present generating equipment consists of two 22x42-in. Corliss engines, direct-connected to 300-kw. direct-current 230-volt generators running at 110 r.p.m. and one 18x22x18-in. duplex compound direct-connected to a 125-kw. generator of the same type and operating at 230 r.p.m. Provision is made for the installation of two additional units. The main lighting and control board is shown at the left in Fig. 1. The three-wire system of distribution is used, and individual switchboards are provided in each building for the distribution of light and power service.

The boiler plant consists of eight 3,000-sq.ft. Stirling boilers, arranged in two rows facing a central aisle, as shown in Fig. 2. The four units on the left were installed when the plant was first built and are equipped for burning coal, although certain modifications have recently been made for using fuel oil in two of them. The battery on the right is equipped for oil burning exclusively and has been in operation since 1919. The original boilers, at the left, are furnished with Dutch-oven furnaces and overfeed stokers, the coal being fed through chutes from overhead bunkers.

As the coal is received, it is dumped from trucks into a hopper from which it is fed through a crusher to a bucket conveyor and is delivered either to a storage bunker of 1,500 tons capacity or directly to the overhead bins, as may be desired. These overhead bins

*Consulting engineer, Boston, Mass.

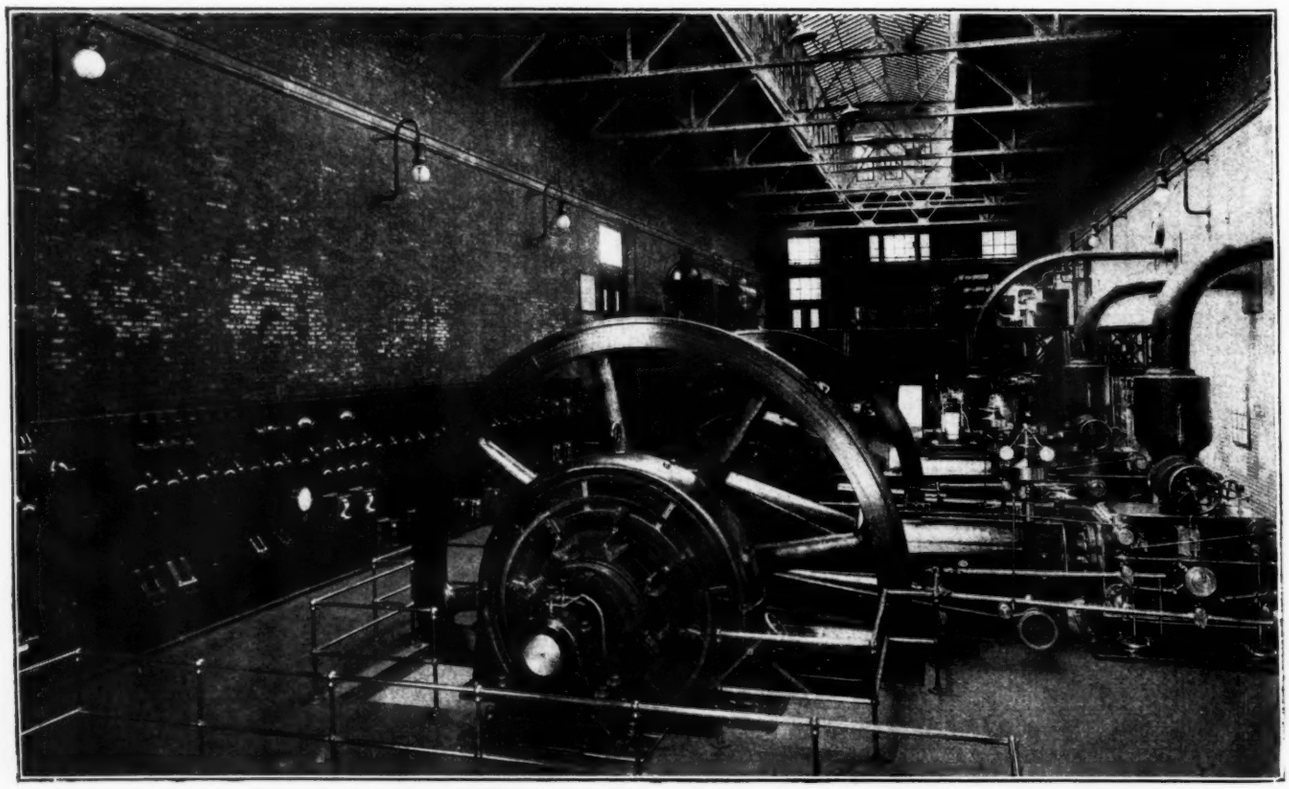


FIG. 1—VIEW OF ENGINE ROOM, SHOWING GENERATING UNITS AND SWITCHBOARD

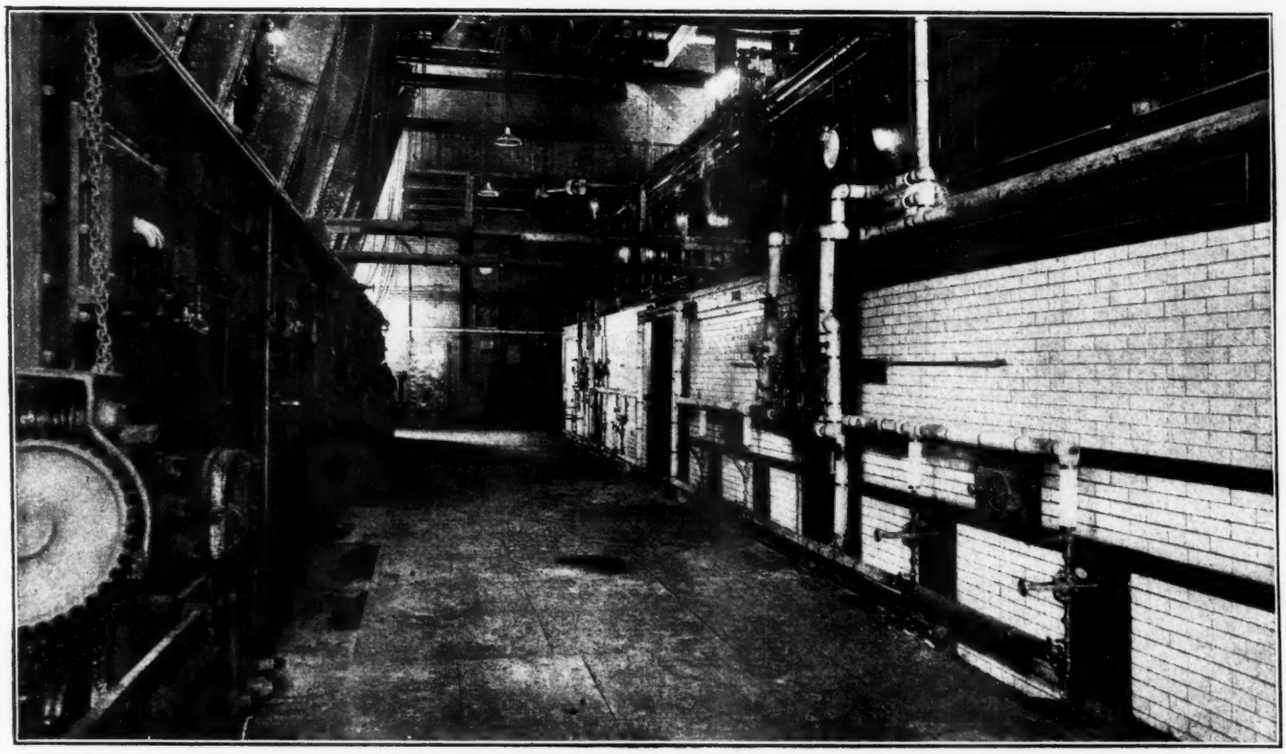


FIG. 2—CENTRAL FIRING AISLE, SHOWING STOKERS AND OIL-BURNING EQUIPMENT

have a capacity of 30 tons each and rest on scales so that all the coal used may be accurately measured when desired. Refuse from the ashpits is shoveled directly into the coal conveyor and delivered to an overhead bunker from which it is discharged through a chute to trucks for removal.

Oil has been used exclusively as a fuel for two years and a half with satisfactory results. In order to guard against any interruption in the service due to shortage of oil, the stokers and coal-burning equipment have been left intact in the four older boilers, with the exception of the removal of the grates from two of the units and the introduction of oil burners. In case of an emergency the two boilers so equipped may, on short notice, be changed back for burning coal, thus giving sufficient capacity for supplying the entire plant with steam by operating at a reasonable overload under maximum conditions. The oil burners used are of the steam-atomizing type, two being used in each furnace. The oil is pumped to the burners under pressure directly from the storage tank. The pumping equipment consists of two complete pumping units, each having two pumps and an exhaust steam heater, thus providing a spare unit to facilitate inspection or repairs.

During cold weather the oil is heated sufficiently in the storage tank to allow it to flow freely to a secondary heater at the pump. Between the pumps and burners a live-steam heater is provided to raise the temperature to the required point for atomization. As automatic regulation is essential to economical boiler operation, one automatic regulator is provided for each four burners. These regulators control the oil fed to the furnace and the steam supplied to the burners; also the position of the smoke-pipe and ashpit dampers in exact relation to the oil burned.

Heating is done partly by forced hot water and partly by steam, according to the general requirements. The hot-water system is employed where all the rooms are to be maintained at practically the same temperature, but in the buildings where it is necessary to vary the temperature in the different rooms, steam is used, as it is more easily regulated. In some of the buildings both systems are installed, hot water being employed for warming the corridors and a portion of the buildings, as previously stated, while the wards are heated by steam, using the return-line vacuum system with graduated supply valves on the inlet to the coils and radiators.

The general layout of the piping for the hot-water system is shown in Fig. 3, and that for steam in Fig. 4, which also includes the "service" steam system. These two diagrams make no distinction in the number of buildings, each group being represented by a single rectangle. All distributing pipes for steam, hot water, brine and compressed air, together with electric wires and cables, are carried between the buildings in underground tunnels.

Two independent sets of equipment are used in connection with the system of forced hot-water heating, each consisting of exhaust and live-steam heaters, circulating pumps and indicating equipment.

Each outfit is provided with two vertical exhaust-steam heaters and one live-steam heater of the same type, the latter taking steam at full boiler pressure and returning the condensation by gravity. The temperature of the water supplied to the buildings is regulated by varying the height at which the condensation stands in the live-steam heater, thus varying the amount of exposed tube surface and thereby increasing or diminishing its heating capacity as may be desired. A chart has been prepared, based on experience, showing the water temperature required in the flow main for warming the buildings under different outside temperatures when circulating a given volume per minute through the system.

Indicating instruments show the gallons of water

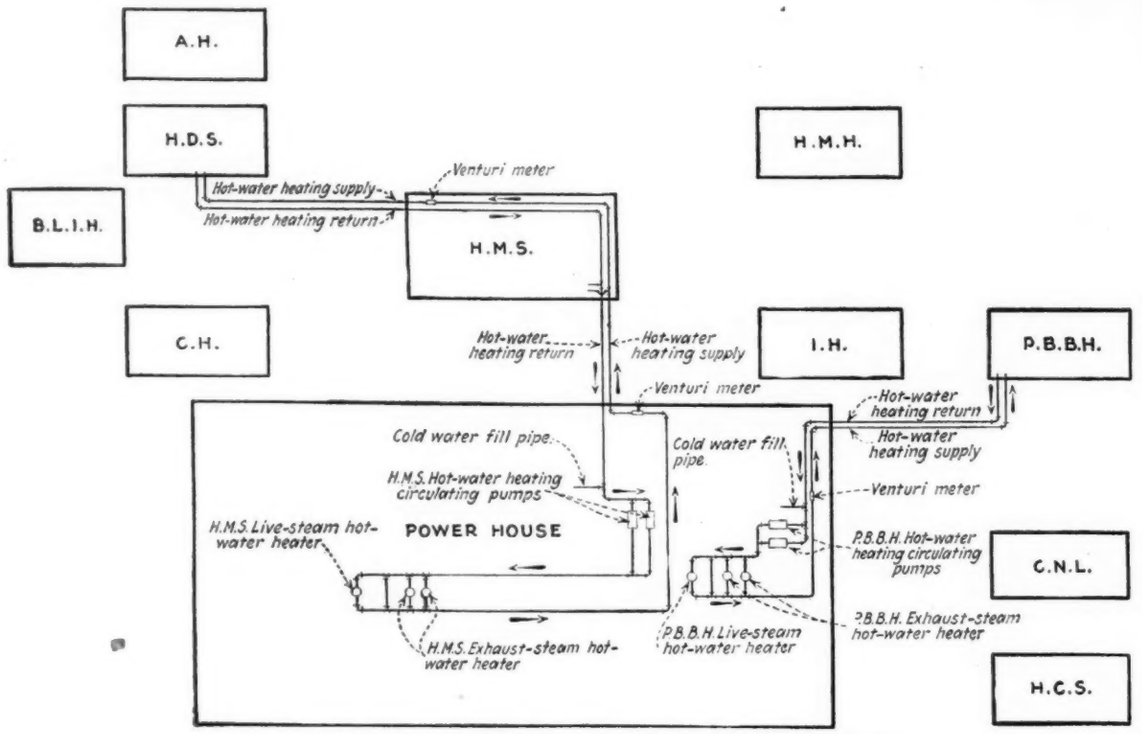


FIG. 3 PIPING DIAGRAM OF HOT WATER HEATING SYSTEM

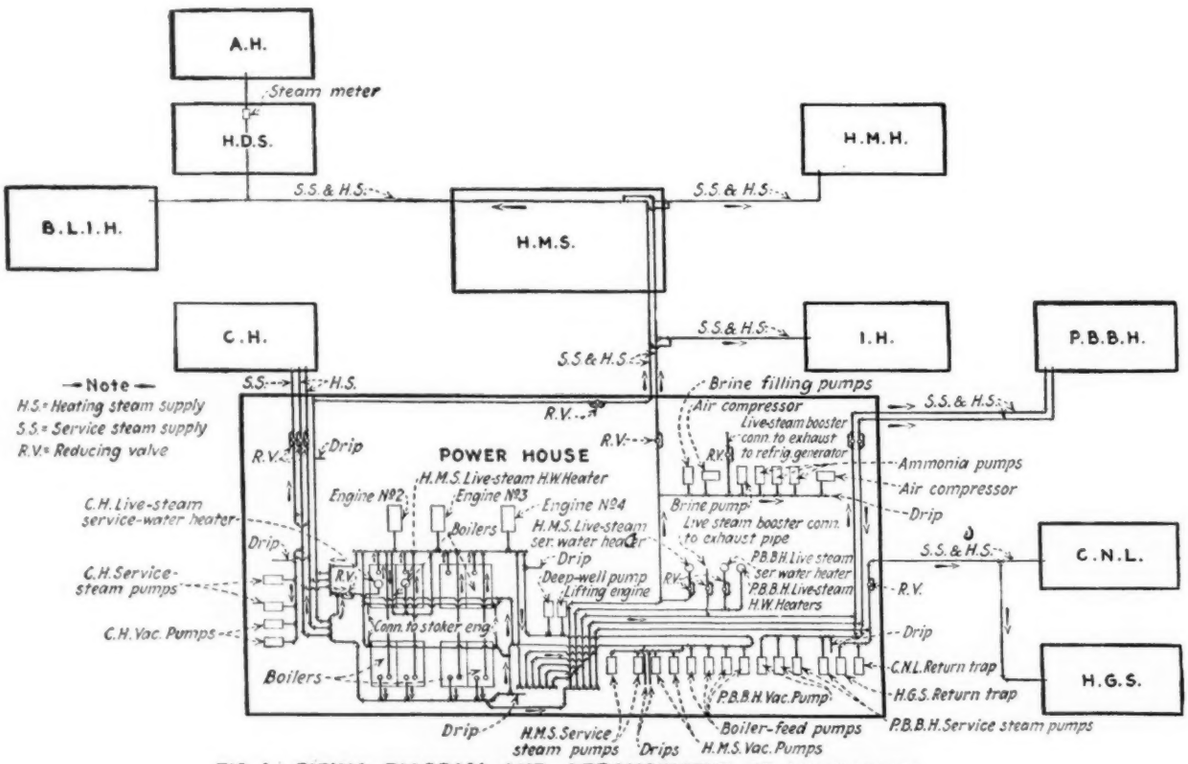


FIG. 4 - PIPING DIAGRAM AND ARRANGEMENT OF AUXILIARIES

circulated per minute, also the temperature and pressure in both the supply and return mains, and record the temperatures in both pipes continuously. The amount of condensation from the live-steam heaters is measured and recorded by venturi meters, while the rate of condensation taking place at any time is read directly from a dial. Certain relations between the rate of condensation in the heater and temperature in the flow main have been determined (with the exhaust heaters in use) so that it is a simple matter to adjust the capacity of the heater to the actual requirements at any time by means of valves located beside the indicating apparatus.

The pumping equipment consists of two centrifugal pumps with a normal capacity of 2,000 gal. per min., each driven by a direct-connected variable-speed motor, having a range from 275 to 550 r.p.m., and two centrifugal pumps of 1,000 gal. per min. capacity, driven by a variable-speed motor having a range from 500 to 1,000 r.p.m.

The returns from the vacuum heating systems are brought to three sets of duplex pumps, located in the power house. All returns from the steam-heating systems are metered and discharged into a feed-water heater, from which they are returned to the boiler. All the condensation from exhaust steam which may contain oil, is first passed through a coke filter and then to a "Deoleizer," a device containing a material that absorbs any oil which the water may contain after passing through the filter. When the absorbing material becomes impregnated, the oil is burned out in a furnace and the material used over again.

The drips from all pipe lines carrying steam free from oil are connected to a receiving tank in the power house and pumped to the feed-water heater. Wherever possible, condensation from any source, throughout the entire group of buildings, is metered and returned to the feed-water heater. In connection with the system of meters just mentioned, there is provided a special device for calibrating them at regular intervals of once a month or so, as may be necessary for obtaining accurate results.

Unavoidable losses are made up automatically by fresh water from the city mains which is discharged into the feed-water heater as required. The feed pump installation consists of two 14x8x12-in. duplex pumps of the pot-valve plunger type, and two 9x5½x10-in. duplex pumps, used during light-load periods and as stand-by equipment.

For part of the hot water heating, a system of heaters different from that already mentioned is employed. The water is first passed through a single exhaust-steam heater and then raised to the required temperature in supplementary low-pressure live-steam units, automatically controlled. The water is circulated through the system by motor-driven turbine pumps, and the necessary recording instruments are provided.

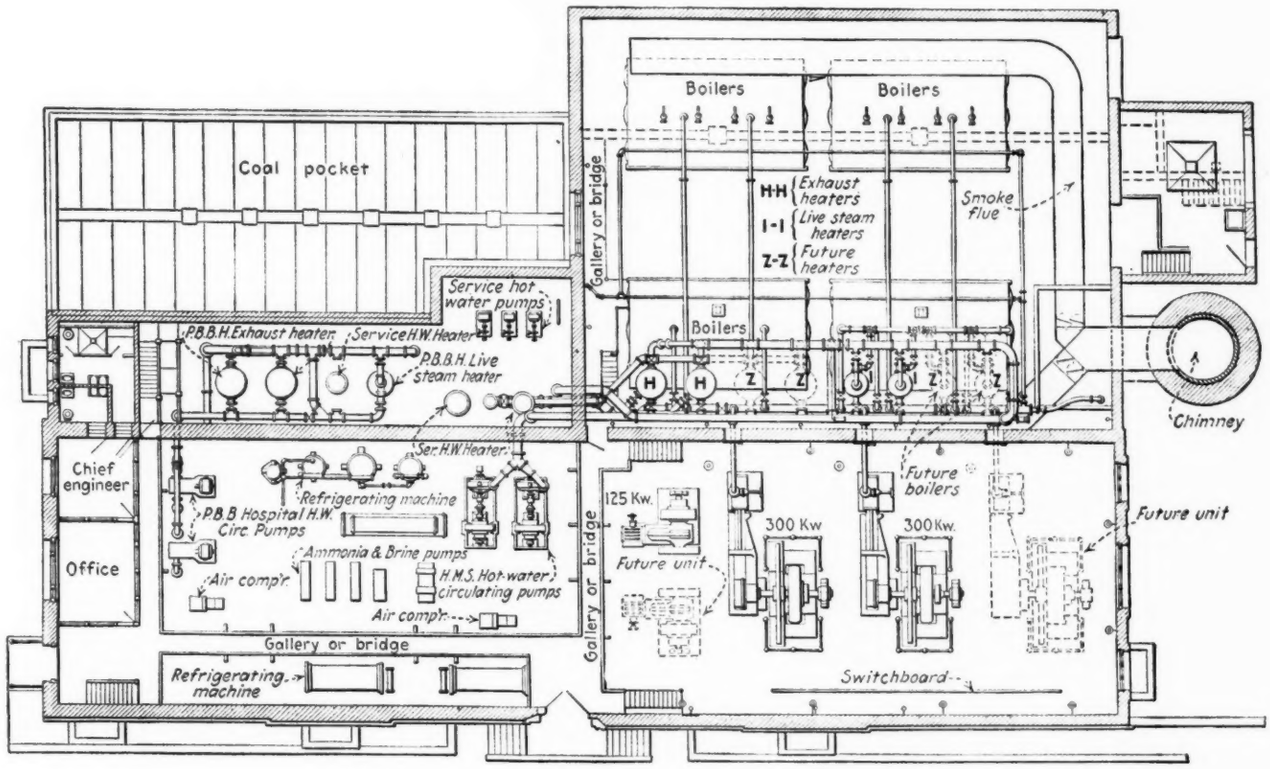


FIG. 5—ARRANGEMENT OF PLANT EQUIPMENT

Refrigerating Equipment

Refrigeration is furnished by two 50-ton absorption machines (one being held in reserve) located in the engine room. No ice is made in the power house, but equipment is provided in the hospitals for utilizing the cold brine for this purpose to the extent required. Water for cooling is obtained from three artesian wells, one of which is provided with a steam pumping head and the other two with electrically driven pumps.

In order to have reserve refrigeration available at all times, a brine storage tank of 6,000 gal. capacity has been provided and so piped that one pump circulates brine between the machine and the tank while another forces it through the buildings. In order to reduce heat loss to the lowest possible amount in connection

with the refrigerating plant, a heater is installed, and so arranged that the incoming makeup water from the city mains absorbs the heat from the outgoing hot water to the sewer, thus making a substantial saving in the course of a year.

This same policy of reclaiming heat, wherever possible throughout the entire plant, has been developed to a high degree. The refrigerating equipment, like that for heating and steam supply, is well provided with indicating instruments, and the temperature of the brine tanks is taken every two hours.

Compressed-Air System

Compressed air at a pressure of about 30 lb. is supplied to the different institutions for various purposes such as temperature control, cleaning, laboratory work, etc. Two steam-driven duplex compressors are provided for this purpose—one a 7x9x10-in. and the other a 6x8x6-in. They are both located in the engine room, one being held in reserve.

The oiling system for the equipment in the engine and pump rooms consists of two pressure tanks, a filter and reservoir, and the necessary piping. In operation one of the tanks is charged with oil and city water pressure admitted at the bottom. This forces the oil to the bearings and sight-feed lubricators. The overflow drains back by gravity to the filter, and from here it is discharged into the second tank, which, during this time, it not under pressure. When the first tank is nearly empty, the connections are reversed by a shifting of valves, and pressure is applied to the full oil tank, which then feeds the system while the other is filling from the filter.

All ordinary repairs about the plant are taken care of in a well-equipped machine shop in the basement of the power house. As the basement of the plant is below the level of the city sewerage system, all drainage is handled by electrically driven sump pumps. All important equipment throughout the plant is in duplicate. This is especially necessary in case of central service for a group of hospitals, as no interruption can occur without possible serious consequences. In Fig. 5 is shown the general arrangement of the generating units, auxiliary, and boiler-room installation.

Stop Valves and Header Connections

By W. H. WAKEMAN

THE process of connecting two or more boilers to a header, which is common to all of them, appears to be a simple matter, but there is a principle involved in the proper installation and operation of the pipes and valves, and where this has been ignored it becomes a source of constant care to prevent accidents of more or less importance. The principle may be briefly stated as follows:

Whenever the steam space of a boiler is to be connected to a header, the safety of this operation should not depend on the manual adjustment of a drip valve, as the draining should be automatic.

An infraction of this rule that is dangerous in practice is shown in Fig. 1. The globe stop valve is about 12 in. above the boiler. It is followed by a long-sweep elbow, a horizontal pipe and another elbow. Suppose that this boiler is laid off for inspection. Steam from the header condenses until nearly the entire space above the valve is full. Steam is again raised, and the boiler is ready to be cut in. If the stop valve is opened first, it is practically sure to cause a serious accident. The only safe way is to have this drip valve always open and connected to a reliable trap.

As it is difficult to open a globe valve cautiously, a gate valve, as illustrated in Fig. 2, is preferred. It is a strong form of construction, but water can break the strongest valve made. This is a slight improvement, as a larger part of the water drains back into the boiler automatically, but there is space enough above the valve to make it dangerous under some conditions.

Fig. 3 is an improvement, but it is not recommended. Water drains from one side of the valve into the boiler and from the other side into the header, but this is a globe valve with a vertical stem, hence the seat is high enough to prevent complete drainage. If the stem were horizontal, it would be much better.

In Fig. 4 is shown an angle valve with a horizontal stem. It is impossible to have water hammer with this design, because the drainage is automatic and complete at all times. There is no necessity for caution so far as water hammer is concerned, and even if there is great difference in the pressure on the inlet and outlet, it requires only ordinary practice to make it safe.

By some engineers an angle valve is considered a weak form of construction, on account of the bolted bonnet, but it is just as safe as a globe valve when designed for the same pressure. When this valve is shut and the boiler to which it is connected is laid off, the stem can be packed. It is claimed that modern valves may be opened wide and packed under full boiler pressure, but it is not always safe to try it.

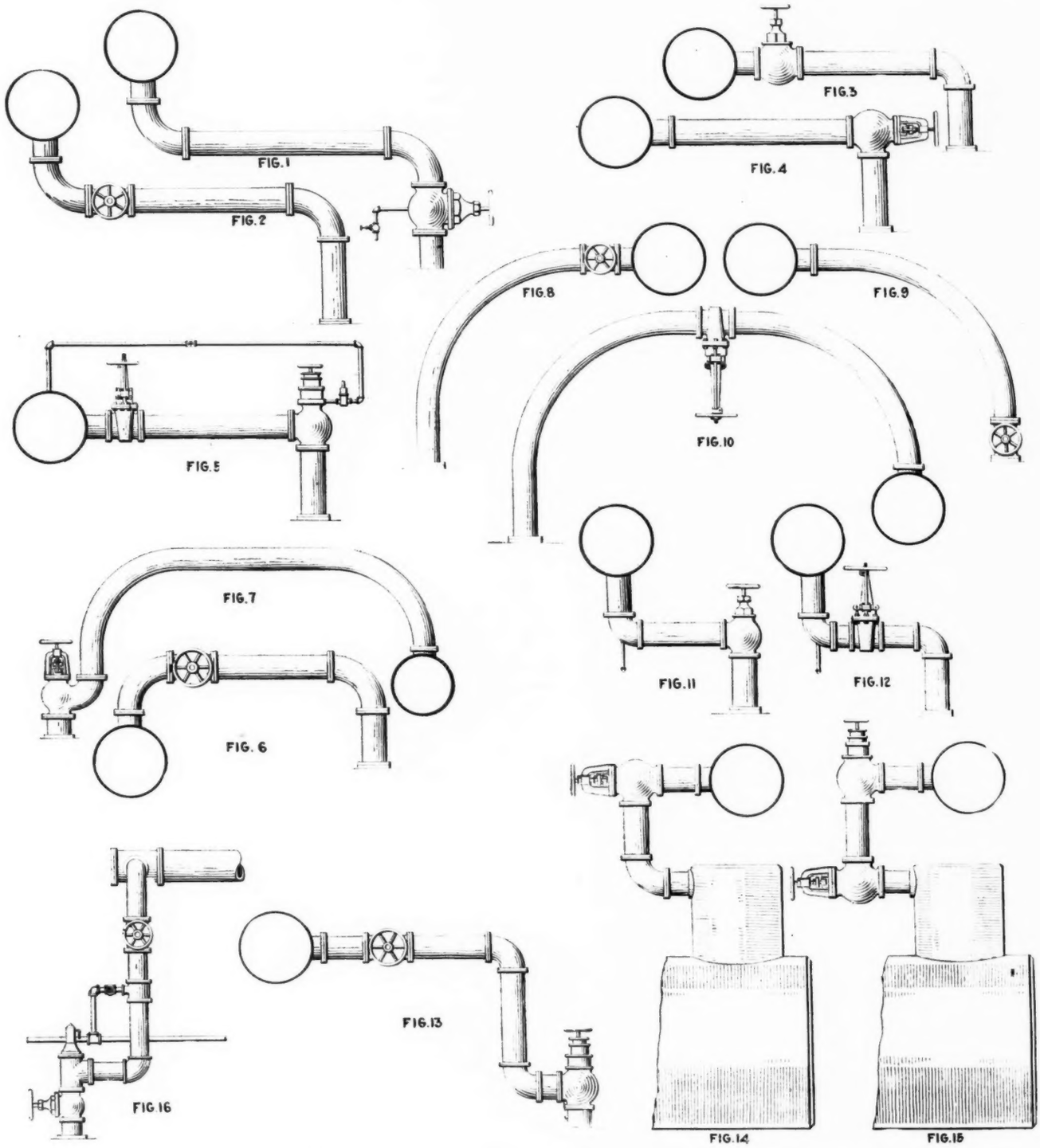
Fig. 5 illustrates an angle non-return valve and a gate valve between it and the header. This combination has one good feature—it offers no obstruction to free drainage so far as the angle valve is concerned—but there is a chance for a mistake to be made in operating the gate valve. This valve is convenient, as it enables the engineer to shut off the header, and by laying off the boiler it is possible to adjust or repair the non-return valve without cutting out the entire header.

Suppose that repairs are completed and steam is raised in this boiler. Assume that the gate valve is tight. Under a few pounds pressure the angle valve will open and admit steam to the horizontal pipe. As the pressure becomes equal, this valve closes and some of the steam is condensed. When it opens again, it will admit steam to this entrapped water, which is not safe practice. A better plan is to open cautiously the gate valve first, then the automatic valve will operate just as if there were no other valve on the line.

A good design of piping where the header is below the top of the boiler is shown by Fig. 6. A gate valve is used and water of condensation drains away from it automatically in both directions. This combination is safe under almost any operation to which it can be subjected, as it will never cause water hammer. Fig. 7, however, is about the worst combination that can

be devised. Water will always collect in the bend above the valve when the latter is closed for any purpose, and no provision is made for disposing of it, consequently when the valve is opened, water hammer must follow.

valve is closed, steam from the header will collect in the bent pipe above it, and there is no drip valve to open to drain the water. If one is provided, it may be opened slowly with safety, because it is not drawing



DIFFERENT LOCATIONS FOR STOP VALVES AND CONNECTIONS TO BOILER AND HEADER

Fig. 8 illustrates the gate stop valve and long-sweep pipe bend used on one battery of boilers in my plant. It works perfectly in practice as the draining is always complete. Fig. 9 seems to be similar to Fig. 8, but in reality it is about as different as can be devised, so far as results in practice are concerned. When the water out of a horizontal pipe, therefore the water cannot surge back and forth, striking a blow at each change of direction, but must follow the lowering water line.

With a long-sweep bend there are but two joints between the valve and the header and one below the

valve, which is about as simple as it can be made, but this is not an important feature. When such a pipe is full of comparatively cool water, it should be drawn very slowly in order to prevent vibration. For this purpose a drip pipe should not be larger than ½-in. for all sizes of connections that are likely to be used. If this rule is followed, it will be impossible to draw off the water too fast. An objection may be raised to this, because this size is frail and liable to be broken accidentally. A regular ½-in. pipe has an internal diameter of $\frac{5}{8}$ in., hence if extra-strong pipe is used it will be thick enough to withstand all legitimate shocks and still have ½-in. internal diameter. If it is possible to connect this drip pipe into a main return pipe that is always under boiler pressure, it will keep the header connection free from water. The drip pipe must not be connected into the feed-water pipe, as that is frequently under more than boiler pressure, hence it could not discharge freely. It ought to include a check valve to prevent water from backing up into the header connection and thence into the header.

Fig. 10 illustrates a form of connection that is not as free from the effects of contraction and expansion as it appears to be. A vertical outlet from the boiler, and the same kind of inlet to the header, with an ell on the top of each, would prove more flexible. More joints would be necessary, but that is not a serious objection. The piping drains in both directions without a drip on either side of the valve. The gate valve is inverted for convenience of operation. There is one in my plant, and no objectionable feature has developed in a long term of service.

An Especially Bad Feature

Fig. 11 is located in my plant, and is one of the worst features that I have known. Three boilers in a battery are fitted with stop valves and header connections of this design. Without the small drip pipe shown, water would collect in both the horizontal and the vertical pipes. This drip pipe is only ½-in., and was originally fitted with a globe valve. The first and only time that I opened this valve to let water escape, the water hammer was severe.

The three drip pipes are connected into a horizontal pipe, which discharges into a main return pipe that takes the condensation from the header at other points. There are no valves on these three drips, hence they cannot be closed. The operation in practice is as follows: When one boiler is laid off for inspection, shutting the stop valve does not interfere with the drainage system. When it is fired again until steam is raised, and the stop valve is opened, steam flows from the boiler into the header or in the opposite direction (according to which carries the higher pressure) without shock or vibration, regardless of the difference in pressure. If all three of the boilers are laid off and steam from another battery fills the header, these connections are still drained automatically. The valves on these separate drip pipes were removed to prevent their being closed when they ought to be open, but there is a valve on the main return pipe for emergency use, but it is seldom closed. It is safer to have these drips discharge directly into the boilers, as there is then no danger of their failure to operate.

When it is necessary to pack the stem of the angle valve shown, pressure must be removed from the header, or in other words, the plant must be shut down for this purpose. Fortunately, it is only a short job.

Fig. 12 is similar to Fig. 11, except that a gate valve is used, thus giving details for those who prefer this kind of a valve. The stem is vertical, which is correct for a gate valve in a steam line.

Fig. 13 shows a design that is approved by some engineers, but it has a dangerous feature. Near the boiler an angle stop and non-return valve is installed with a gate valve in the horizontal pipe. We are informed that where an automatic valve of this kind is in use when a boiler is to be laid off, it is only necessary to reduce the pressure and the automatic valve will close and prevent steam from flowing into the boiler. When the boiler is fired up again, what would happen? The vertical pipe would be full of water, hence the steam coming from the boiler would create a violent commotion. Of course a drip pipe could be provided but it is better to design the piping so that none would be necessary, because the fireman might forget to open it.

Design Sometimes Recommended

Fig. 14 is a fair design that has been recommended for use where the header is directly over the domes and near to them. It will work well in some cases, but under unfavorable conditions the joints will leak on account of expansion and contraction. The remedy is to provide longer pipe connections so that the whole will be less rigid. The stem of this valve can be packed without removing the pressure from the header.

Fig. 15 illustrates a similar boiler and header with a good design for an automatic non-return valve with a vertical stem, and a horizontal angle valve. This is not an ideal design, because the automatic valve is next to the header, but it is the best that is practical with the dome and the header in this relative position.

Fig. 16 shows a globe valve next to the boiler, followed by a flanged tee, on the top of which is a pop safety valve. The outlet from this tee carries a nipple followed by an elbow and another nipple. The reducing tee provides for a small steam line, and above it is another valve. The worst feature of this design is that by closing the lower valve, the safety valve becomes useless, thus leaving the boiler without this protection.

Even if this valve was located on a separate outlet, the remainder would present a defective design, as it is necessary to depend on a hand-operated drip valve to remove water from the connection, before cutting in the boiler after inspection. If the pipe had been carried directly upward from the boiler nozzle, with an angle valve on a level with the header, it would have drained automatically in both directions, with less joints to make and maintain. The reducing tee could occupy the same relative position.

Where flanged joints are adopted for this work, they can be quickly installed, and if alterations are to be made later on, they can be taken down without injury, but for regular low-pressure service, screwed joints are best because it is never necessary to pack them.

The new book, "American Fuels," by Bacon and Hamor, gives the following ratios of fixed carbon to volatile matter: Anthracite, from 10 to 60; semi-bituminous coal, from 3 to 7; bituminous, less than 3. These ratios, taken by themselves, are not sufficient for the complete classification of coals. Consideration must be given to the physical characteristics, such as color and general appearance, hardness, ability to stand handling and storage, etc.

Measuring Resistance of Grounds

By M. Oldacre

Ground resistances vary from time to time unless ground-rod, wire or plate is sunk deep in the earth (more than 6 ft.); or unless the connection with earth is made by materials such as water pipes, railroad tracks and similar objects presenting a large surface in contact with the earth. During the hot summer months earth resistances often increase and so cause unexpected troubles by introducing high resistance in the ground circuit. This may lead to shocks, fire hazards, failure of relays to operate and the shunting of current through cable sheaths.

Reasons contributing to higher earth resistance during the summer are that moisture dries out of the soil, so reducing the conductivity of the earth in the neighborhood of the ground connection; the earth cracks under the influence of alternate heat and moisture, introducing air spaces in the ground circuit; and polarization at the ground rod occurs. If a ground connection is important and if it is worth having, it is worth maintaining, so that it is often well to check up the resistance during the hot weather. Many fires, lightning troubles and failure of control apparatus to function properly can be charged to defective ground connections.

A low ground resistance is desirable, but one that is permanent and not a variable one is, perhaps, even more important. In measuring these resistances, it will be found often that the results differ so widely and change so erratically that suspicion is aroused as to whether they are worth anything. The fact is that because of the presence of electrolysis, electrochemical action, polarization and the concentration of resistance at the contact between soil and ground rod, ground resistance measurements may be unreliable. However, reliable results may be obtained in the following manner:

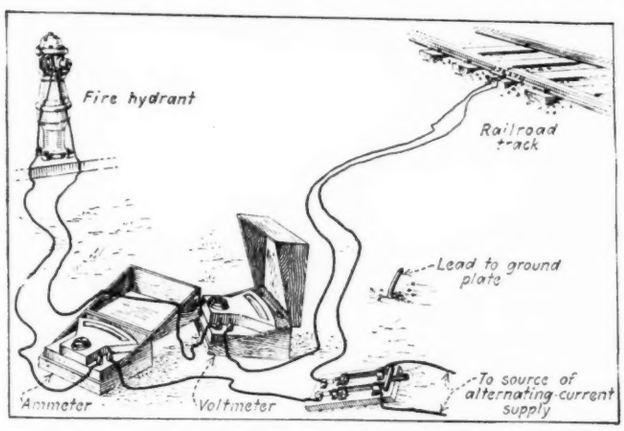


FIG. 1. CONNECTIONS FOR TESTING RESISTANCE OF GROUND PLATE

There should be three "earths" preferably not closer together than 15 ft. One of these is the ground whose resistance it is desired to measure. The other two may be a water pipe and some other "ground" not in metallic connection with either of the other two. Voltage is applied between each pair of "grounds," 110 volts of alternating current generally producing a flow of between 25 and 50 amperes between the "earths." Both current and voltage should, of course, be measured simultaneously and noted for each set of readings. Alternating current is preferable to direct current as it eliminates the effects of electrolysis and counter-electromotive force. If only direct current is available, the errors due to polarization can be reduced by using a higher voltage and heavier current than suffices for alternating current, for example, 200 volts.

An ammeter and a voltmeter are required, and preferably a rheostat, to control the current. Two, or better still, three, readings of current and voltage should be taken between each "pair" of grounds, that is, between ground plate and rail, plate and water hydrant or pipe, and between pipe and rail. The results should be averaged and the resistance for each of the three tests determined. The diagram, Fig. 1, shows the connections for making the test, and a good method of tabulating the instrument readings is given in Fig. 2.

	A PLATE-TRACK		B HYDRANT-TRACK		C PLATE-HYDRANT	
	ACTUAL READINGS	AVERAGE	ACTUAL READINGS	AVERAGE	ACTUAL READINGS	AVERAGE
Volts						
Amperes						
Resistance = Volts / Amps.						

FIG. 2. FORM FOR COLLECTING TEST DATA

Let A be the circuit between ground plate and railroad track, B that between track and water pipe or hydrant, and C that between ground plate and hydrant. As two resistances exist in each circuit these can be represented thus: $A = R_1 + R_2$; $B = R_2 + R_3$; $C = R_1 + R_3$, where R_1, R_2 and R_3 are the individual resistances of ground plate, rail and water pipe respectively. A, B and C are determined by the voltmeter-ammeter readings and after dividing the current into the average voltage.

Actual tests gave the following average values of resistance:

$A = R_1 + R_2 = 15$ ohms (between plate and rail).
$B = R_2 + R_3 = 6$ ohms (between hydrant and rail).
$C = R_1 + R_3 = 12$ ohms (between plate and hydrant).

The individual values of R_1, R_2 and R_3 are readily found by eliminating each of the unknowns, thus:

Subtracting $R_1 + R_2 = 12$ from $R_1 + R_2 = 15$ gives $R_2 - R_3 = 3$. By adding $R_2 - R_3 = 3$ to $R_2 + R_3 = 6$ gives $2\,R_2 = 9$, from which $R_2 = 9 \div 2 = 4.5$ ohms. $R_1 + R_2 = 15$, then $R_1 = 15 - 4.5 = 10.5$ ohms and $R_2 + R_3 = 6$, therefore $R_3 = 6 - 4.5 = 1.5$ ohms. From this it is seen that the resistance R_1 of the ground plate is 10.5 ohms; R_2, the resistance of the track to earth, 4.5 ohms; and R_3, the resistance of the water pipe to earth, 1.5 ohms.

It is good practice to check up important ground resistances periodically with the seasons or after a heavy rush of current, as it shows if they are "drying out." Leaving current on before taking readings for the calculations also often serves to show the same thing by a gradual decrease of the current. The ammeter-voltmeter method is suitable for city and industrial use; it is simple and reliable, while the instruments are usually on hand.

Notes on Air-Compressor Lubrication

By W. F. OSBORNE
Supervisor Manufacturers' Service, Texas Company

THE lubrication of the bearings of an air compressor is in no way different from the lubrication of the same kind of bearings on a steam engine, and the same sort of oils are used. The air cylinder, however, presents an entirely different proposition.

An air cylinder is lubricated primarily to reduce friction and prevent wear. The lubricant also has the additional duty of assisting the piston rings in the formation of a seal to reduce the leakage of air past the rings, thereby improving the efficiency of the compressor.

Mechanical Conditions Similar to Those in Steam Cylinder

The mechanical conditions within the air cylinder are very similar to those within the steam cylinder. A film of oil must be deposited on the cylinder wall and maintained in sufficient quantity to prevent metallic rubbing of piston and cylinder wall. The same properties of viscosity, surface tension and volatility are influential in the formation and maintenance of the film.

Instead of steam we have air within the cylinder and thereby many peculiar troubles arise. Air is drawn into the cylinder at ordinary temperatures, varying from as high as 110 deg. F. down to zero if the compressor happens to be located out of doors in winter weather. During the suction stroke the oil film on the cylinder wall is exposed to such low temperatures that there is practically no effect on the oil film whatever. During the compression stroke the temperature increases as the pressure rises until just before the discharge valve opens, when the maximum pressure is reached.

The temperature existing within the cylinder at this moment depends on the pressure reached at the end of the stroke and the initial temperature of the air. When air is compressed to 50 lb. gage in a single cylinder, with an initial temperature of 70 deg. F., the discharge temperature may reach 340 deg. F.

These high temperatures exist only near the end of the stroke, and the greater part of the oil film is never exposed to such temperatures because it is covered by the piston. Furthermore, the oil is in contact with the cylinder wall, which is cooled by the circulating water or by radiation to the atmosphere when water is not used. As a result the average temperature of the oil film on the wall never gets very high, probably between 125 and 150 deg. F. At such temperatures the viscosity of the oil is not seriously reduced, and oils may be used which are much lower in viscosity than those required for the higher temperatures of steam cylinders.

Evaporation at Low Temperatures Small

Evaporation at these low temperatures is small, and the oil film, once formed, is easily maintained with an extremely small amount of oil supplied from the lubricator. If it is fed to the cylinder directly at the top or near the top on the sides, the small quantities required cause the oil to enter the cylinder slowly and the piston spreads it over the surface of the cylinder. If too large quantities are fed, it will run down the piston and will be scoured off by the air and carried out through the discharge valves.

Evaporation takes place most rapidly at the end of the cylinder where the oil film is exposed to the highest temperatures. For this reason it is sometimes considered desirable to feed the oil at each end to replace that evaporated. If the feed is direct through oil holes in the cylinder, most of the oil is quite likely to be wiped into the counterbore of the cylinder by the piston before it has been of very much service.

Many cylinders are also lubricated by depending upon the air to atomize the oil and carry it to the cylinder wall somewhat in the manner of the steam cylinder. The difficulty of such a method is the low temperature of the incoming air, which does not atomize the oil thoroughly, although it will carry it in a liquid state to the cylinder wall, where most of it will adhere, being thrown out of the air stream by centrifugal force.

The cylinders of vertical inclosed-crankcase, single-acting compressors are lubricated by the splashing of the oil onto the cylinder wall when the piston is at the upper end of its stroke. The oil works past the piston rings and lubricates the upper part of the cylinder also.

Viscosity the Chief Factor for Consideration

The quantity of oil getting into the cylinder depends upon the viscosity of the oil, the rate of splashing by the connecting rods, the piston and ring clearance and the mechanical design of the piston, including such provision as may be made for draining away the excess oil. The oil is also expected to assist the rings in maintaining a proper seal, preventing excessive leakage of air into the crankcase and thereby increasing the efficiency of the compressor.

Considering the mechanical side of the problem, the principal property of the oil that the engineer has to consider is its viscosity. In general the recommendations that follow will be found to give satisfactory service as far as lubrication is concerned:

	Saybolt Viscosity
Single-stage, horizontal or vertical double-acting:	
Pressures to 50 lb.	290-310
Pressures to 100 lb.	700-800
Two-stage, horizontal or vertical double-acting:	
Pressures to 50 lb.	190-210
Pressures to 100 lb.	290-310
Multi-stage, horizontal or vertical double-acting	290-800
Single-stage, vertical inclosed crankcase, splash lubricated:	
Pressures to 50 lb.	290-310
Pressures to 100 lb.	700-800

These viscosities are for naphthene oils; paraffin oils should have viscosities about 10 per cent lower in order to get the same results.

When compressors are to be operated outdoors in winter weather, the oil should have a sufficiently low pour test so that it will remain fluid at the lowest temperature likely to be encountered.

Having selected the proper viscosity and pour test, the question arises as to what kind of oil should be used, whether filtered or non-filtered, blended or straight-run, pure mineral or compounded, high volatility or low volatility, high carbon residue or low carbon residue, etc. All these properties have a bearing on the formation of carbon deposits, the principal source of trouble in the air compressor. This is such an important subject that it will not be dealt with here, but will be taken up in the next article.

25,000 Hp. Engine Built in England

IN THESE days of steam turbines of ever increasing size and power, a reciprocating engine of 25,000 hp. is something of an achievement. Such an engine was recently built for the Carge Fleet rolling mills, one of the largest in England. As will be seen from the illustration, it is built mainly on marine lines, and it was constructed by a well-known marine-engine firm, Richardsons Westgrath, of Middlesbrugh, who kindly placed the photograph at our disposal.

There are three simple cylinders 45 in. in diameter and 52 in. stroke, all taking steam at 190 lb. and 100 deg. superheat. The speed is 140 r.p.m., at which there is a torque of 417 foot-tons.

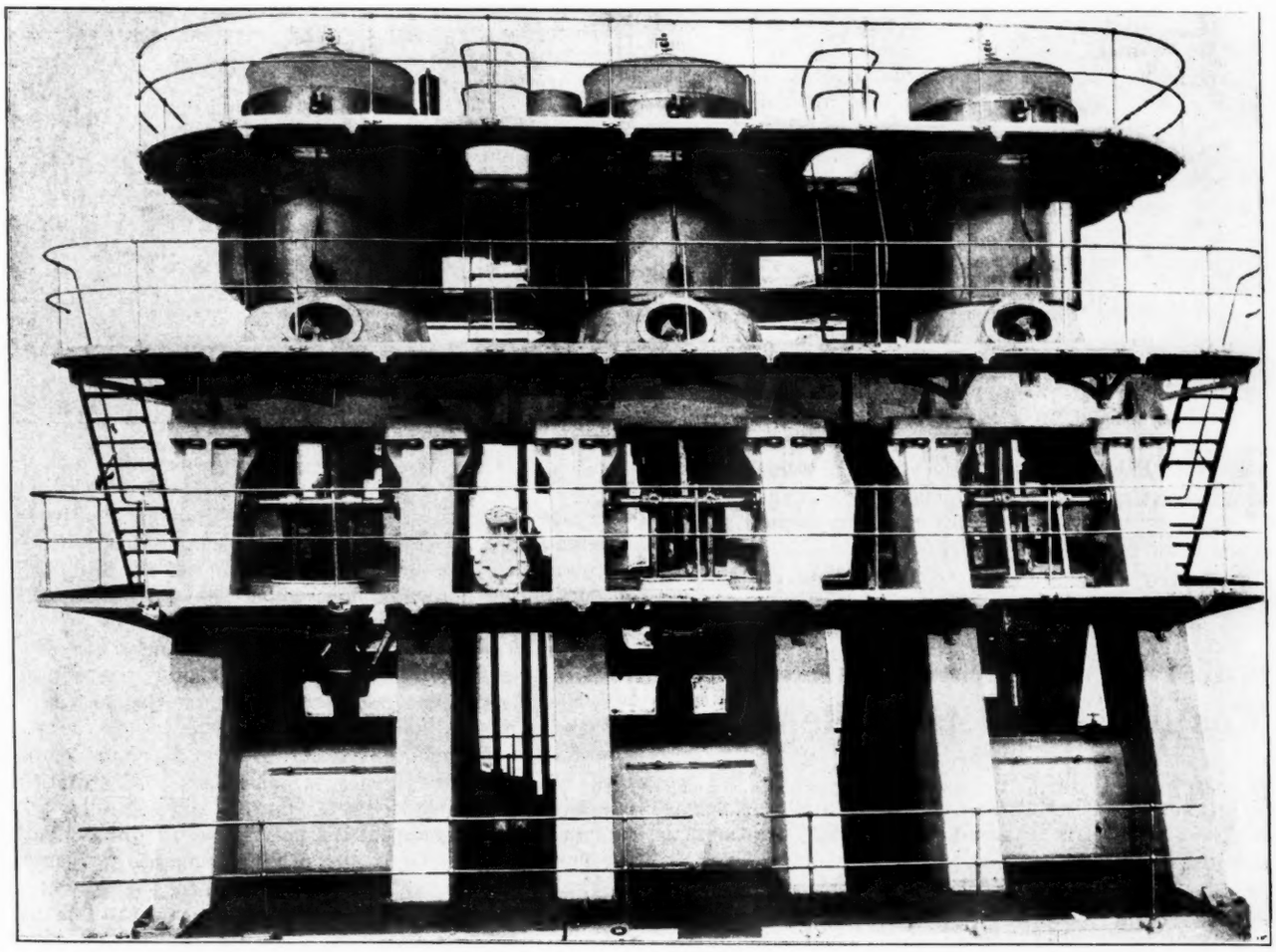
The engine was built for the purpose of speeding up the rolling of 24x12-in. steel joists and other similar sections, and it is required to reverse four times per min., no mean performance, considering its size. A special valve gear is necessary for this. Such reversals entail heavy sections for the main frame, etc., and the very wide base shown. This is secured to a heavy concrete foundation. The bedplate measures 22x29 ft. and weighs 105 tons.

There are six main columns of the inverted Y shape, made in two parts with a planed joint down the center. These are bolted together and specially strengthened by hoops cast on to bosses inside the joint. The bearings shown on the columns carry the main reversing shaft. The entablature which carries the three cylinders is built up of three castings 2 ft. deep and bolted together by deep flanges, while the crosshead guides are also bolted to it, thus helping to tie the whole frame.

Liners are used in the cylinders, the intervening space between cylinder wall and liner serving as a steam jacket. The cylinder bottoms are in the form of cone-shaped standards, the inside of which provides ample room for a man to work at the stuffing boxes, the entry doors being seen just above the third platform. The valve chambers are separate castings bolted to the cylinders, the valves being of the balanced piston type 20 in. in diameter. They work in separate liners.

Exhausting over the ends, these valves take steam at the center through a 14-in. double-beat throttle valve placed close to them. The latter are separately adjustable, but they can all be operated simultaneously from the driving platform by means of a steam-hydraulic reversing engine.

A Joy type of valve gear is employed, a pattern popular with locomotive engineers. Nickel steel valve spindles are used, and the pins of the motion are casehardened and work in bronze bushes.



BUILT ALONG MARINE LINES AND OF MASSIVE CONSTRUCTION TO MEET HEAVY DUTY

The reversing engine referred to, which is, of course, essential in view of the heavy gear to be put in motion and the frequency of the operation necessary, is of the direct-acting steam-hydraulic type and practically identical with similar reversing engines used in marine practice. The cylinder of this reversing engine is seen next the second column from the left.

The crankshaft is built up of three sections, bolted together by flanges. Each section consists of two webs and a pin forged out of one ingot, with two short lengths shrunk on and pinned to the webs. Both shaft and pins are hollow, being bored 5 in. in diameter. The body of the shaft weighs over 40 tons and is 22 in. in diameter, and the whole shaft was trued up in the lathe after being bolted together. The main bearings are 22 in. in diameter by 24 in. long. They are lined with white metal, are interchangeable, and water-cooled.

Connecting rods are of the usual forked end marine pattern, while the piston rods are 9 in. in diameter and of forged nickel steel. The pistons are steel castings machined all over and rest on a collar on the rod. They are secured by steel nuts, 8 in. in diameter and having a fine thread.

The engine has no governor as ordinarily understood, but there is an emergency master valve in the main steam pipe which comes into action when the speed exceeds 12½ per cent above normal. This is effected by means of a centrifugal weight on the end of the crankshaft, which releases the hydraulic pressure which normally keeps the valve open.

Needless to add, in view of the very severe duty it has to perform, everything has to be both simple and massive, while special facilities were provided for in designing it to permit any inspection of vital parts to be made as easily as possible and any repairs to be effected with the utmost dispatch.

Altogether the engine is an interesting example of a very powerful unit designed for a special purpose.

Water Power as a Substitute for Coal in the Austrian Republic

By J. A. G. Pennington

The Austria of today has very little fuel for power purposes. There is a small quantity of brown coal (lignite) and a fair amount of peat, which, however, is very unsatisfactory for power. Good timber is plentiful, but only the numerous sawmills use wood for fuel. Soft coal, as understood in America, and anthracite do not exist in Austria. Thus there remain only two methods to solve the acute fuel shortage—one is the development of the latent water power, the other the importation of suitable coal. The depreciated "krone" (Austrian crown) makes the coal importation prohibitive, so only the water-power remains, of which there is ample reserve.

There are some old electric stations, but their output is small. As coal formerly was cheap, it did not pay to build hydro-electric plants. Most of the coal came from the old Bohemia and some from Silesia, but since Czecho-Slovakia levies an export duty on coal to Austria, and in addition this must be paid for in Czech crowns, one of which equals about 600 Austrian crowns, water power is becoming cheaper than coal.

The total available water power in the Austrian Republic amounts to a mean annual yield of 2.5 million horsepower, which is considerable for a population of less than seven million. On the basis of ten hours a day all the water power, fully utilized, would provide a substitute yearly for 11½ million tons of lignite, the only coal available which is considerably the greater part of the quantity of coal which Austria is now obliged to import. According to official estimates seven million tons of coal, now used annually to provide light and power for railways and industries, could be replaced by hydro-electric power.

This development is taking place in provincial units. Each Austrian province, such as Lower Austria, Upper Austria, Salzburg, the Tyrol, Carinthia and Styria, is developing its own water power in conjunction with

HYDRO-ELECTRIC SYSTEM DESIGNED FOR 450,000 HORSEPOWER

the other provinces. All the power stations are to be interconnected. Those in the Austrian Alps will be comparatively small units on account of the difficulty of controlling the water flow, while those in the foothills will be large ones.

The map shows the locations of the various hydro-electric plants to be built by the Styrian Water Power and Electric Co., known as the "Weag," in Styria, which is mostly mountainous in its topography. The water-power development of Styria is used as an example for two reasons: First, Styria possesses the greatest amount of undeveloped water power, and secondly, the financial plan of the whole enterprise is unique and the first of its kind. It gurantees reasonable dividends to the shareholders, ultimate benefit to the province itself and makes provision for the fluctuations in the value of the Austrian currency. From the map one can see that the plants are widely scattered but are interconnected. The total output of these hydro-electric plants is estimated at 450,000 hp., which is about one-fifth of the total available water power in Austria, and will amount to a yearly output of about 1,000,000,000 kw.-hr., which can be delivered to power and light users.

The building program comprises the following: In the territory of the Mur Riber four low-pressure installations—Bruck-Mixnitz, Judenburg-Zeltweg, Puntigam-Werndorf and Peggan-Weinzoedl—and in addition to these the high-pressure works on the Teigitsch River, including storage basin, as maximum and compensating station and the storage (reservoir) and compensating station on the Teichalpe.

In the territory of the Enns River the Enns installation in the "Gesäuse" (a very narrow valley through which the river flows), the power stations on the

Erzbach and Radmer, including the storage basin at the Leopoldsteiner Lake, and finally the power installations and storage basins on the Soelk and Tal streams.

The hydro-electric plants are to be supplemented by steam-power plants in the Koeflachev coal district and possibly in other Styrian lignite (brown coal) mining districts.

To Form an Interconnected System

The aforementioned power-generating stations are to be connected with each other and with the principal consumption centers by high-tension lines of 60,000 and 100,000 volts, so that the greatest possible efficiency and the most far-reaching reduction of operating costs can be obtained through unified operation. In this connection the high-pressure installations combined with the storage basins will have the task of balancing the output of the low-pressure works in case of low water, while the steam-power plants are to take care of occasional peak-load demands and act as reserves in case of breakdown in any of the hydro-electric plants. The installations of the power company will also have the important task of transmitting electric current over long distances.

The generated power of 1,000,000,000 kw.-hr. will to a large extent be consumed by the various industries in Styria itself, among which might be mentioned electrochemical plants through whose help Austria will be able to replace many raw materials from abroad, which the present rate of exchange has made too expensive to import from other countries. In addition to the local industries the Styrian railways, including the Southern Railway, running from Vienna to Trieste, are to be supplied with current as well as parts of Lower Austria and the City of Vienna.

Preliminary calculations, plans and surveys were completed in September, 1921, and on these the concessions for building and operating the plants for 90 years were granted to the "Weag" (Styrian Water Power and Electric Company).

To raise the necessary funds for the construction of the hydro-electric plants, the "Weag" is to issue bonds, preferred and common stock.

Higher Rates to Meet Guaranteed Construction Costs

Until 75 per cent of the original building costs have been paid off, Styria will renounce its right to fix the rates for electric current. Therefore these will be kept as high as compatible with the principles of sound business and the "Weag" will, with the consent of the consumers, endeavor to earn profits in excess of the normal amount in order to write off some of the building costs. The net profits of the "Weag" will remain tax free in accordance with the Austrian federal law of recent date, until three-quarters of the original building costs remains on the books, but the rates must be sufficient to guarantee a dividend of at least 6 per cent. The redemption of bonds and preferred stock is, as a rule, to keep in step with the amortization of the original cost of real property (plants and transmission lines), so that when the book value of the latter has been reduced to 25 per cent of the original, only the common stock remains as liability, which must be redeemed during the course of the 90-year concession period.

The holders of preferred shares which have been redeemed according to lot will be given "rights" entitling them to participate in the real property until all preferred shares have been redeemed, whereupon these rights will be exchanged on the basis of 5 rights for 1 share of common stock.

After the 75 per cent tax-free writing off has been completed, an appraisal of the actual value of the entire property must be made in Austrian currency, and then this sum must be translated into some stable currency at the then existing rate of exchange. The real native worth of the entire property, which has thus been determined and which represents the property of the remaining common stock expressed in a stable currency, forms the basic account for figuring the interest on and retirement of the common shares until these have all been paid off.

Detecting Boiler-Plate Cracks

By the etching process developed in the laboratories of the Krupp Company, according to *Practical Engineer*, it is now possible to detect the brittleness in low-carbon steel plates which have been cold-worked and then heated to a blue heat. The plate will show its brittleness at ordinary temperatures, but the fact could not be demonstrated until etching led to the disclosure of exact force influence figures or bands.

Bands were detected not only in old defective boiler plates, but also in new plates after they were heated to 392 deg. F. and straightened in a machine. Force influence bands did not appear in all soft steels and sometimes appeared only in the zone of high-phosphorus segregation, but not in the low-phosphorus surface layers of the plate. Their appearance depends on the composition of the metal.

Temperature has a considerable bearing on the matter. The temperature at which the plate was finished in rolling is important. Plates which left the rolls fairly dark sometimes showed bands, while plates finished in the rolls at a higher temperature were usually free from the bands.

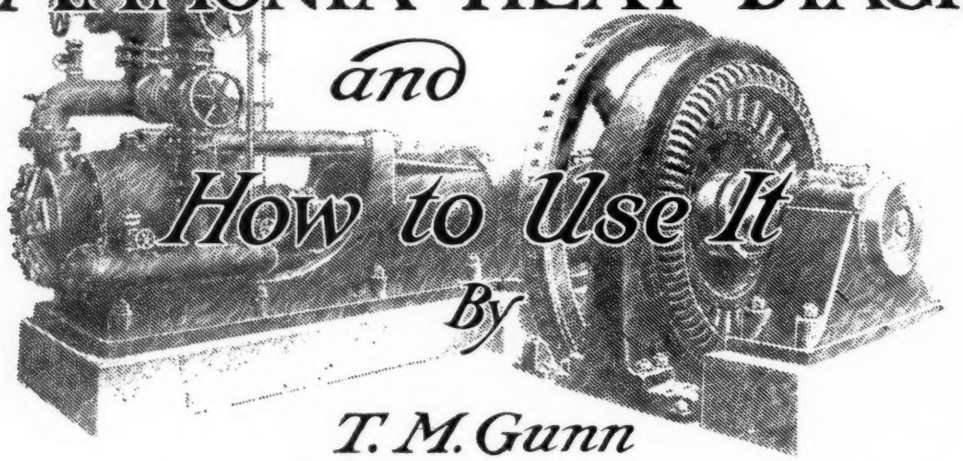
Influence of Annealing Temperature

Influence on the behavior of the plates is exercised by the manner of their annealing. Plates that were annealed above the transformation point, showed force influence lines after bending only in the phosphorus layers, while in plates annealed at a low temperature their presence over the entire cross section was very pronounced.

Notched-bar impact tests on various specimens confirmed the original statement that soft steel worked cold or at blue heat is brittle when tested at room temperatures. It has been found, however, that plates which, after bending and annealing, are brittle at ordinary temperatures, are tough when tested at 392 deg. F., regardless of any previous treatment they may have received.

From these circumstances it is held that boiler material shows in most cases a much higher toughness in the warm condition than in the cold; that the formation of cracks is promoted by allowing the boiler to cool off, and that in many cases cracks are caused by the impact effects when cleaning the boiler or calking it, a result that might be prevented by properly appreciating this condition and taking due care to avoid it. This may explain how microscopic cracks can lead to large cracks during the hydraulic test through the impact effect of the pump stroke, or may lead to an explosion through the breathing of the boiler.

The Ammonia Heat Diagram and How to Use It



By T. M. Gunn

THE chart of properties of ammonia shown in Fig. 1 has been prepared from the data given out by the Bureau of Standards, making use of the same co-ordinates as on their chart, but changing the scales so as to make them somewhat more readable. A scale has been added for temperature of saturation, and a portion of the original chart that is never used in ordinary refrigeration calculations has been omitted, thereby giving room to use the larger scales that have been selected.

Those who have used the Mollier Diagram for Ammonia, as shown in *Power*, Nov. 29, 1921, will be quick to realize that the method selected by the Bureau of Standards for plotting the diagram has many advantages. As to accuracy there is no doubt that their experiments have given the engineering world the first data that can be regarded reliable over the full range of ordinary use.

Use of Chart Is Easily Learned

Not only can designers and technical engineers make use of this chart, but its application is so direct and clear that operating engineers can easily master its use. It is possible to work out many problems regarding their own plants, which may result in greatly improved operation. As will be shown, only the simplest arithmetic is involved in the calculations, and formulas are not required. The principles are the same as outlined for the "Total Heat Diagram for Steam," in *Power*, Aug. 22, 1922, page 286.

The first essential is to understand the meaning of the chart and to be able to read it correctly. It tells the story of one pound of pure anhydrous ammonia. Any point on the diagram represents this pound in a certain condition, defined in terms of its pressure and its heat content.

Pressures are indicated by the top and bottom scales, which read in absolute pressures—meaning that atmospheric pressure must be added to the reading of a correct gage before the pressure is used on the chart.

Heat content, which is generally one of the answers sought in our problems, means the amount of heat possessed by the pound of ammonia above that of a pound of liquid ammonia at 40 deg. below zero F. (—40 deg. F.). This temperature of —40 deg. F. is taken as a convenient starting point. Heat content can be read from the scale at the right or left of the chart. It is measured in British thermal units (B.t.u.) per pound of ammonia.

Like water, ammonia may be a liquid, it may be boiled away to a vapor and the vapor may be heated above the temperature of boiling liquid, when it is said to be superheated and has all the properties of a gas.

When the liquid is in a condition just ready to boil, it is called "saturated liquid." This condition is represented by any point on the line on the diagram marked "Saturated liquid." Below this line is the liquid region, where any point represents a pound of liquid ammonia at a certain pressure and a temperature below that of saturation.

As a pound of ammonia is boiled away to vapor, an increasing fraction of the pound becomes vapor, until at last the entire quantity is evaporated. When the evaporation is just completed, it is called "dry saturated vapor." This condition is represented by any point on the line so marked on the diagram. This is vapor at the boiling temperature and carries no liquid.

Between the lines marked "Saturated liquid" and "Saturated vapor" is what is called the "region of saturation." Any point in this area represents the pound of ammonia in a partly evaporated condition. The fraction of the pound that is vapor can be read from the lines marked "Quality."

It will be noticed that a strip of the saturated region (between 180 and 450 B.t.u. heat content) has been omitted from the chart. This part is not used in refrigeration problems, and its omission permits the introduction of the scale for temperature of saturation, and in other ways assists in the arrangement of the chart. This temperature scale applies to the region of saturation but not above or below it and shows the boiling temperature at any desired pressure.

When heated beyond the condition of saturated vapor, the ammonia becomes a superheated vapor. The part of the chart above the line of "dry saturated vapor" represents the superheat region. A series of lines in this region are marked to indicate temperatures.

For the regions of saturation and superheat a series of lines enables the user of the chart to read off the volume, in cubic feet per pound of ammonia, for any condition. There is also a series of "lines of adiabatic compression" (constant entropy lines) by which the changes of condition can be traced during the process of compression. Although this process varies in prac-

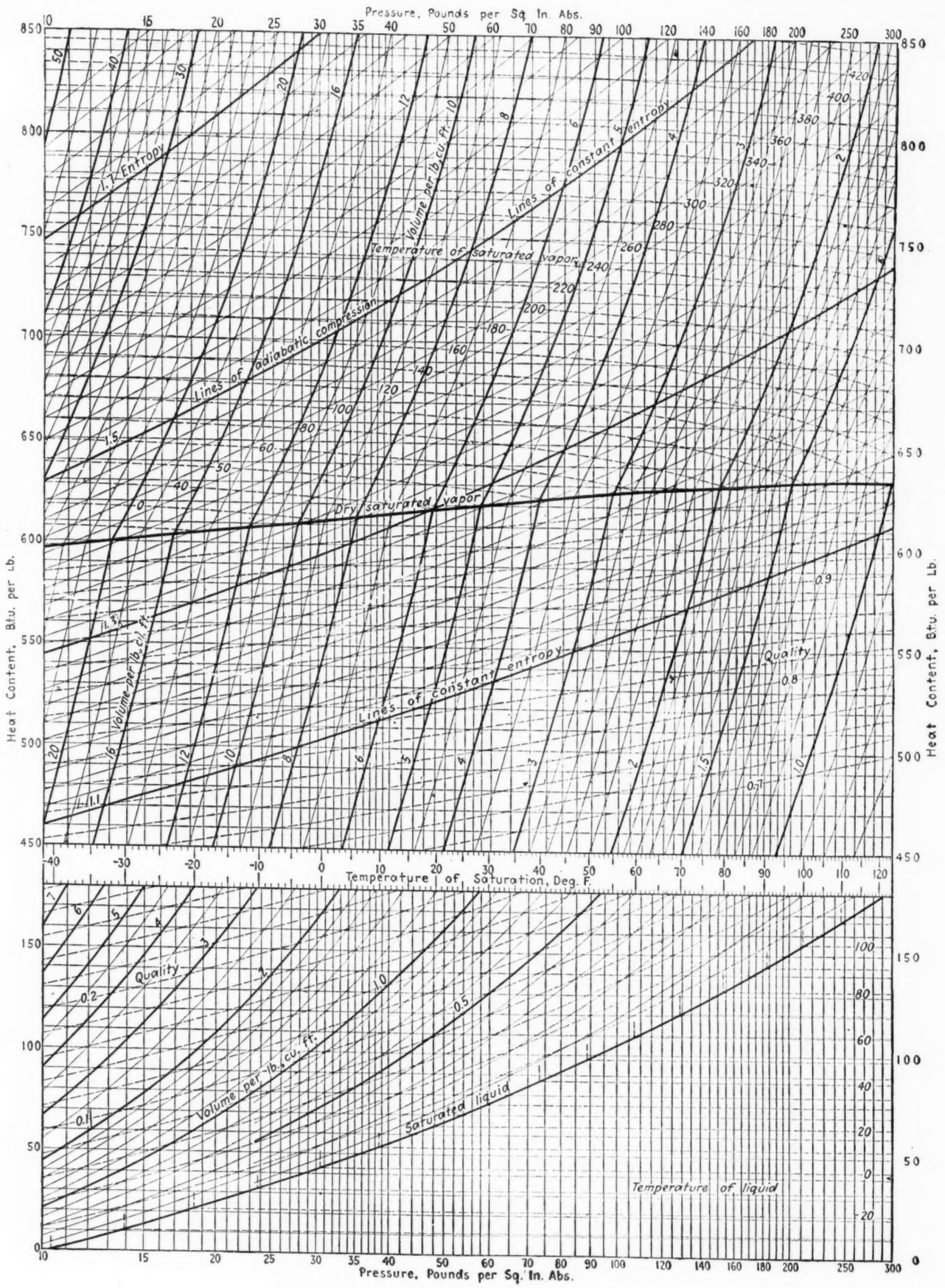


FIG. 1—TOTAL HEAT DIAGRAM FOR AMMONIA

tice slightly from the adiabatic lines, they are the best guide and basis of comparison. Compression would be adiabatic if no heat were given to or taken from the ammonia during compression. There is a small amount of heat exchanged with the cylinder walls, its amount being less than in the ordinary steam engine using saturated steam and probably less than in an engine running on superheated steam.

EXAMPLES OF THE USE OF THE CHART

Problem—In a certain plant, located about 1,300 ft. above sea level, is an ammonia compressor having a suction capacity of 200 cu.ft. per min. (calculated from piston area, stroke, speed and volumetric efficiency). Assume that there is no forecooling of liquid (that is, the liquid ammonia enters the expansion valve at the condenser temperature) and that ammonia vapor passes from the evaporating coils to the compressor in a dry saturated condition. With a condenser pressure of 150 lb. gage and evaporating coil pressure of 20 lb. gage, what amount of refrigerating effect can be expected and how much cooling water is required to give a rise of 8 deg. in its temperature? Also, what should be the indicated horsepower of the compressor?

Pressures—At sea level mean the atmospheric pressure is 14.7 lb. per sq.in. and decreases about 0.54 lb. per 1,000 ft. altitude, so that at 1,300 ft. altitude the deduction is 1.3 × 0.54 = about 0.7 lb., giving a mean atmospheric pressure at the location of this plant of 14 lb. Adding this to the gage pressure, condenser pressure = 150 + 14 = 164 lb. per sq.in. absolute. Evaporating coil pressure = 20+ 14 = 34 lb. per sq.in. absolute.

Temperatures—The temperature of saturation, corresponding to condenser pressure of 164 lb. (read from chart) is 84 deg. F. That corresponding to evaporating coil pressure of 34 lb. is 4.7 deg. (The fraction of the degree can be estimated closely by the eye with practice.)

Plotting the Cycle—The cycle is plotted in Fig. 2, which is a minature of the main chart, Fig. 1. Liquid ammonia at the given condenser pressure and temperature (164 lb. absolute and 84 deg. F.) is represented by the point *A*.

It passes through the expansion valve from a high to a low pressure without loss of heat, and therefore is represented by a horizontal line, *AB*, on Fig. 1. This line ends at *B*, at a pressure of 34 lb., representing the condition as to pressure, volume and heat content of the ammonia entering the coils.

Evaporation of the ammonia in the coils is an absorption of heat at constant pressure, and therefore is represented by a vertical line *BC* extending to the point on the dry saturated vapor line (as assumed in the problem). The point *C* represents the condition of the ammonia (now a vapor) at the compressor suction.

Compression next takes place along an adiabatic compression line *CD* (constant entropy line) to the condenser pressure. At the end of compression at *D* the ammonia is a superheated vapor (since *D* is in the superheat region). It next passes to the condenser, where the superheat is removed and the vapor condensed to liquid at constant pressure *DA* by the cooling water. This completes the cycle.

Readings from the Chart—From the scales for heat content, read off the values of heat content for each point: for *A* and *B* the value is the same, 137 B.t.u. per lb.; for *C*, 613 B.t.u.; for the point *D*, 710 B.t.u. per lb. Read also, from the curves for volume per pound, the volume of the vapor as it enters the compressor, at the point *C*. This is seen to be a little over 8, say about 8.2 cu.ft. per pound.

Pounds of Ammonia Compressed per Minute—Since the compressor has a suction capacity of 200 cu.ft. per

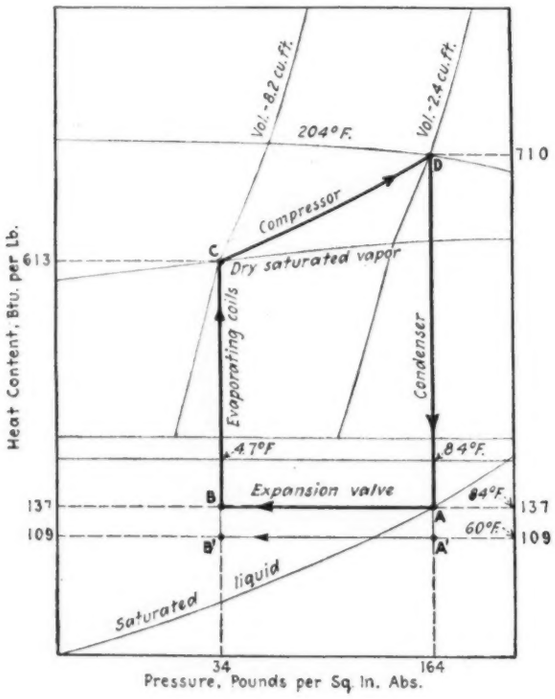


FIG. 2—THE REFRIGERATING CYCLE ON THE TOTAL HEAT CHART

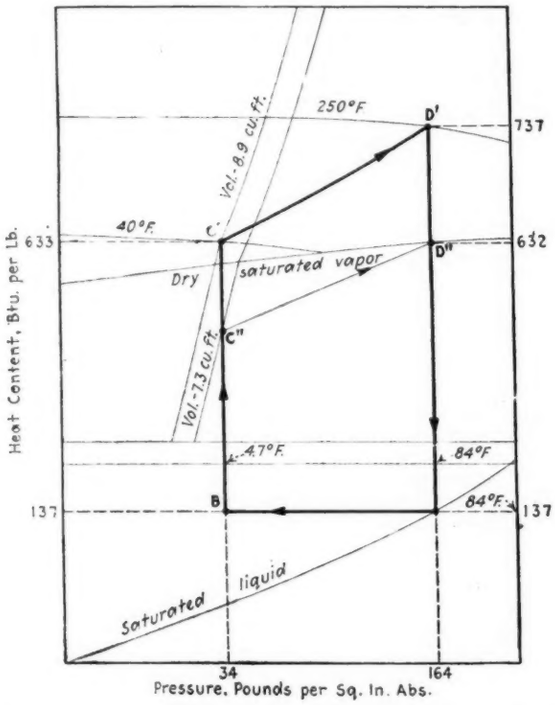


FIG. 3—EFFECT OF WET COMPRESSION AND SUPERHEATED SUCTION VAPOR

min. and each pound of ammonia occupies 8.2 cu.ft., dividing 200 by 8.2 gives the number of pounds of ammonia compressed per minute, which is 24.4 lb.

Refrigerating Effect—In the evaporating coils each pound of ammonia absorbs an amount of heat equal to the difference between the heat content at *C* (613 B.t.u.) and at *B* (137 B.t.u.), which is 476 B.t.u. For the entire 24.4 lb. of ammonia per minute, the heat absorbed is the product, $24.4 \times 476 = 10{,}614$ B.t.u. per min. Since the effect of one ton of ice melting in 24 hours is the absorption of 200 B.t.u. per min., the refrigerating effect in tons is obtained by dividing 10,614 by 200, which gives 53 tons per 24 hours. This answers the first question of the problem.

Cooling Water—Each pound of ammonia gives up an amount of heat to the cooling water equal to the difference between the heat content at *D* (710 B.t.u.) and that at *A* (137 B.t.u.), or 573 B.t.u. per lb. For 24.4 lb. per minute, multiplication gives 13,981 B.t.u. per min. given to the cooling water. Each pound of water, if heated 8 deg., will absorb about 8 Bt.u. Divide 13,981 by 8, and the result is 1,748 lb. per min., or about 210 gal. per min.

Power of the Compressor—During the adiabatic compression *CD* no heat passes into or out of the ammonia save that due to the work of compression. That is the meaning of the word, adiabatic. But after the compression the heat content at *D* is greater than before at *C*. This difference is $710 - 613 = 97$ B.t.u. per pound of ammonia. This increase in heat content is the result of the mechanical work done during compression, and the amount of the increase is the heat equivalent of the work done in the compressor. For the entire 24.4 lb. of ammonia per minute the increase in heat content is $24.4 \times 97 = 2{,}367$ B.t.u. per min. Just as one horsepower is equal to 33,000 ft.-lb. of work per minute, in the same way one horsepower is equivalent to 42.42 B.t.u. of heat energy. To learn what the indicated horsepower of the compressor should be, it is only necessary to divide the heat increase per minute, 2,367, by 42.42, which gives 56 hp.

It is interesting to note how easy the foregoing calculation is compared with that for horsepower based on pressures and volumes, which is too complicated to introduce here. It is sufficient to say, for those familiar with the pressure-volume calculation, that the diagram gives the volume (2.4 cu.ft.) after compression, in addition to that before compression. These two volumes and the pressures enable one to calculate the value of the exponent of the expansion curve, which can be used in the formula for work or horsepower. This independent calculation gives practically the same result as that of the last paragraph.

Temperature after Compression—It is often useful to learn by means of this chart what the temperature should be after compression. In the case of this problem the chart shows a temperature at *D* of about 204 deg. F. When the thermometer shows that the actual temperature is much more than what the chart indicates, there is something wrong in the operation of the compressor, which should be corrected. It may be that the vapor enters too warm, or the piston rings may be leaking, or the valves may not be opening freely or may not seat properly. Any of these causes will result in extra heating and at the same time cut down efficiency.

Example of Liquid Forecooling—If we assume other things to remain the same as in the foregoing problem, but that the liquid ammonia is cooled from condenser temperature (84 deg. F.) before it goes to the expansion valve, the cycle will be represented by *A'B'C'D'* in Fig. 2. The heat content at *A'* and *B'* is 109 B.t.u. The refrigerating effect per pound is $613 - 109 = 504$ B.t.u. The condition at *C* is not changed, so that the same amount of ammonia (24.4 lb. per min.) is compressed. The total refrigerating effect is, therefore, $24.4 \times 504 = 12{,}298$ B.t.u. per min., or 61.5 tons per 24 hours. This has increased the refrigerating effect 16 deg. without changing the power of the compressor.

Example of Superheat in the Suction—Fig. 3 illustrates another modification of the original problem by assuming that the ammonia vapor becomes superheated to 40 deg. F. before it goes to the compressor. Compression is represented by the line *C'D'*. The heat content at *C'* is 633, and at *D'* is 737. The refrigerating effect is $633 - 137 = 496$ B.t.u. per lb. The volume at *C'* is 8.9 cu.ft. per lb. The number of pounds compressed is, the suction capacity of the compressor (200 cu.ft. per min.) divided by 8.9, or 22.47 lb. per min. Total refrigerating effect is $22.47 \times 496 = 11{,}145$ B.t.u. per min., or 55.7 tons per 24 hours. Part of this refrigeration may not be useful, on account of the high temperature of the vapor. The increase in heat content during compression is $737 - 633 = 104$ B.t.u. per lb., or $104 \times 22.47 = 2{,}337$ B.t.u. per min., which is a little over 55 i.hp. After compression the temperature is 250 deg. F. When a high temperature exists here, there is sometimes trouble with lubrication.

Example of Wet Compression—Fig. 3 gives also, by the line *C"D"*, the compression line that is sought in the process called wet compression, when enough liquid is mixed with the vapor in the compressor suction to keep it from superheating. The point *D"* is on the line of dry saturated vapor. The heat content at *C"* is 55 B.t.u. and at *D"* is 632, and the volume per pound at *C"* is 7.3 cu.ft. These figures give 27.4 lb. of ammonia compressed per minute, 56.6 tons refrigeration per 24 hours, and a horsepower of 52.4 for the compressor.

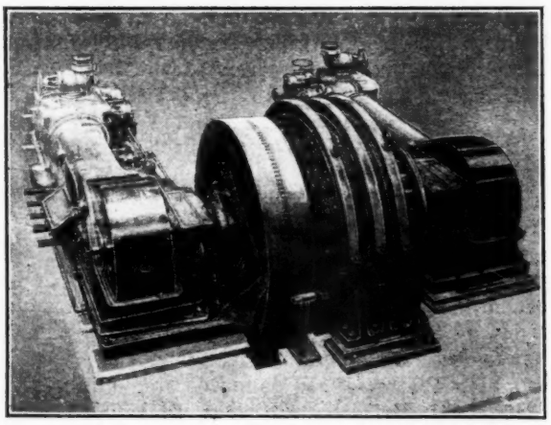
These last two examples are given to illustrate the use of the chart only, and do not represent the relative value of these conditions of operation, because other practical points have a strong influence on their relative desirability.

An ammonia chart of the kind illustrated is a working tool. However confusing its first impression may be to an engineer not accustomed to such a chart, he should, by following the problems here outlined and by the use of chart on similar problems, learn the many uses to which the chart may be put, avoiding much calculation. This chart is merely a scale to measure up the performance of his plant. If it does not fit, there is a reason. Some of these causes for variations are unavoidable, while others are conditions that should be corrected. If nothing else is accomplished, the charting of the performance of his plant will help the engineer to think in terms of what is really happening in the equipment, which is, after all, the most important part of his job.

To clean the evaporating coils of a refrigerating plant it is necessary to transfer the ammonia from the evaporating coils to the condenser, and in case the coils are submerged in a brine tank, the engineer should make certain that there are no leaks before pumping them out. The best method of cleaning is to use steam, which will remove all oil deposits.

Engines at Baltimore Refinery Have Unusual Valve Gear

Twin engines 26 by 32 in., operating at 135 r.p.m., direct connected to a 1,250-kw. direct-current generator; steam admission and exhaust eccentrics carried from end of crankpin; steam valves of non-releasing type, closed by governor eccentric; valve gear mechanism a new development.



IN AN article in the Sept. 19 issue describing the power plant at the Baltimore refinery of the American Sugar Refining Company, the conditions which influenced the selection of reciprocating engines as prime movers were clearly stated. These units were especially designed to meet the requirements of this installation.

The adoption of a twin engine in place of a single unit was influenced largely by the cost of production being less for two similar engines than for one single unit of the same capacity, and the possibility of maintaining a reasonable speed on the generator.

The cranks of the two engines are set at 90 deg. A double governor of the flywheel inertia type is used, substantially similar to the standard Ridgway governor and having the inertia bars of the two sides of the engine permanently tied together with a connecting link, so that they always operate in unison. These inertia bars carry eccentrics swinging across the shaft, and the point of cutoff is determined entirely by the angular advance of the eccentric and is independent of the throw of the eccentric. The governor controls only the point of cutoff and does not affect the opening point of the valves. The valve-operating gear is a new development and has some interesting features. The valves are of the well-known Corliss type, the exhaust valves having double port openings and the steam valves, triple port openings. The valve bonnets and their inclosed mechanism are exactly alike for exhaust and steam valves. The mechanism of these bonnets consists of the valve stem to which is attached a slotted cam which acts as a crank for rotating the valve, and a rockshaft parallel to the valve stem and carrying on one end, outside the bonnet housing, an actuating crank. The other end of this rockshaft, which is inside the bonnet housing, carries a crank having a roller-pin bearing which engages the slotted cam attached to the valve stem. Movement in one direction from the central position of the roller pin opens the valve, while movements of the roller pin in the other direction merely shift the roller pin along the curved cam slot and do not move the valve.

Motion for operating the exhaust valves is taken from a crank inside the engine bed and attached directly to the main engine crank. This crank transmits the motion through a connecting rod inside the engine bed to a rockshaft inside the bed, thence through a crank and rod outside the bed to a secondary rocker and from the lower end of this secondary rocker through rods to the actuating cranks on the valve-bonnet rockers.

The motion of the exhaust valves is fixed and does not change with the load on the engines. The exhaust valves remain absolutely motionless during the admission and nearly the entire expansion of the steam or during the entire time of heavy pressure on these valves.

Motion for the steam or admission valves is derived from two independent sources: First, a fixed crank inside the engine bed and carried by the main engine crank; second, the governor eccentric. These two motions are independently transmitted through rods and rockers to two horizontal main sliding cams placed in the main gear box, which is bolted to the side of the cylinder. Inside the main gear box these two motions are combined and transmitted to a single vertical rocker arm and thence through two short connecting rods to the actuating cranks on the outside of the steam-valve bonnets. The motion from the crank inside the bed is transmitted to the *lower* of the two cams in the main

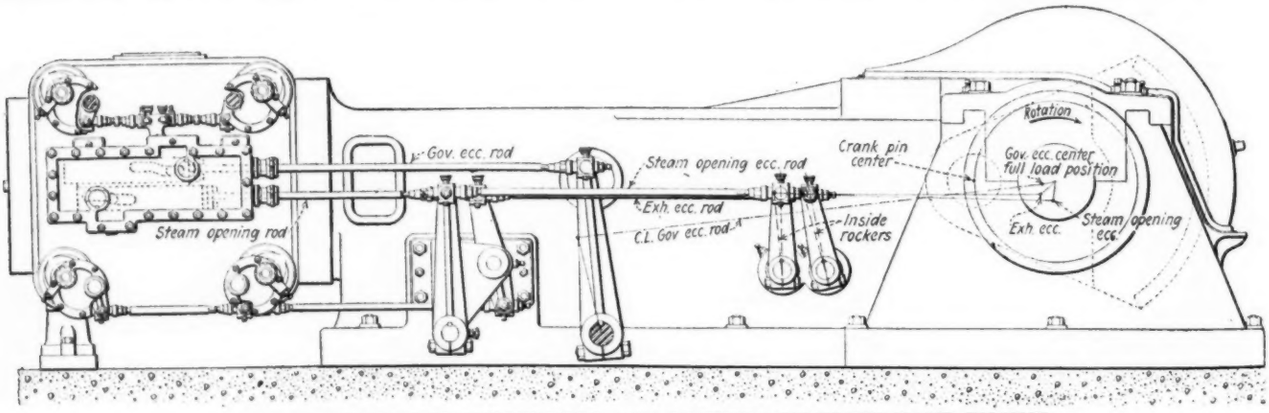


FIG. 1—ASSEMBLY OF VALVE RODS AND ROCKERS ON RIGHT-HAND ENGINE

gear box and the function of this motion is to *open* in turn the two steam valves, thus controlling the *admission* of the steam to both ends of the cylinder. The motion from the governor eccentric is transmitted to the *upper* of the two cams in the main gear box and the function of this motion is to *close* in turn the two steam valves, thus controlling the *cutoff* of the steam and thereby governing the speed and power delivered by the engines.

The mechanism inside the main gear boxes consists of two slotted cams *A* and *B* which have harmonic reciprocating motions derived from a fixed crank for the cam *B* and from the governor eccentric for the cam *A*, as already described. Two small rockers *C* and *D*, each of which carries a pin and roller *P* engaging the slots of the cams, transmit the movement of the cams to a link bar *E* which combines the motions of the two cams. The center of this link bar is connected by a pin and bearing *F* to the lower arm of the vertical main rocker *G*, and the upper end of this vertical rocker, which extends outside the main gear box, is connected by a

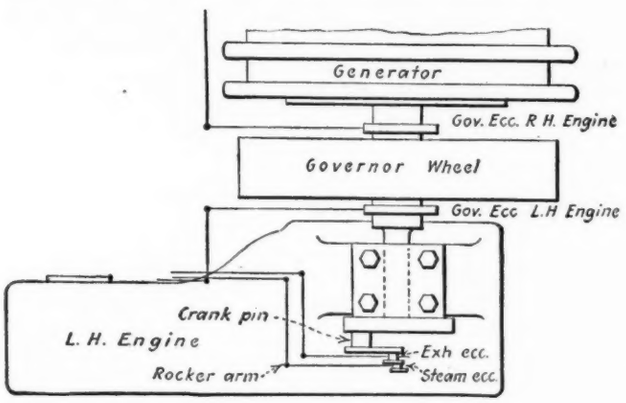


FIG. 2—PARTIAL VIEW OF ASSEMBLY SHOWING LOCATION OF ECCENTRICS AND ROCKER ARMS

short rod on either side to the actuating cranks of the steam-valve bonnets, as already described. The effect of the combination of the two motions inside the main gear box is to give a movement that is very different from a harmonic motion, and this motion is as follows: Starting from a central vertical position, the upper end of the rocker *G*, swings quickly to the right and stops; after a short pause it returns quickly to central position and stops there; after another short pause it swings quickly to left and stops; after a short pause it returns quickly to central position again, thus completing its cycle of motion. The movement to right opens one steam valve and the return closes it. The movement to the left opens the other steam valve and the return closes it. While either valve is being opened and closed again, the other valve is entirely motionless. In the view shown, it will be noted that the opening movement of the steam valves, being derived from a fixed crank, always starts at the same point of the stroke and requires the same amount of time. The point of cutoff only is controlled by the governor and varies according to the load on the engine.

The steam valves have no overtravel beyond the full port opening and at any cutoff later than about one-eighth the valve is opened to its full extent; also, during exhaust the steam valve remains entirely stationary and does not start to open until about two inches from the end of the stroke, at which time compression is built up to a point high enough to permit the easy movement of the steam valve. Oil grooves are cut in the valve cages and oil under pressure is forced below the valves. The steam ports are ½-in. wide and the valves have a steam lap of ¼-in.

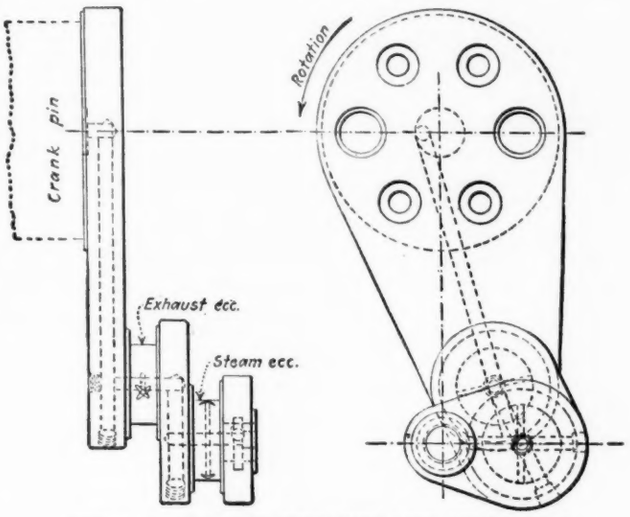


FIG. 3—DETAIL OF EXHAUST AND AUXILIARY STEAM ECCENTRICS

The gear was designed especially to secure the following points in operation: First, quick opening of steam valves and late starting of this movement, thus permitting building up compression and relieving pressure on steam valves before they start to move; second, quick closing of valves and absolutely no motion of the valves after they are closed and during exhaust; third, exhaust valves stationary during admission and expansion of steam.

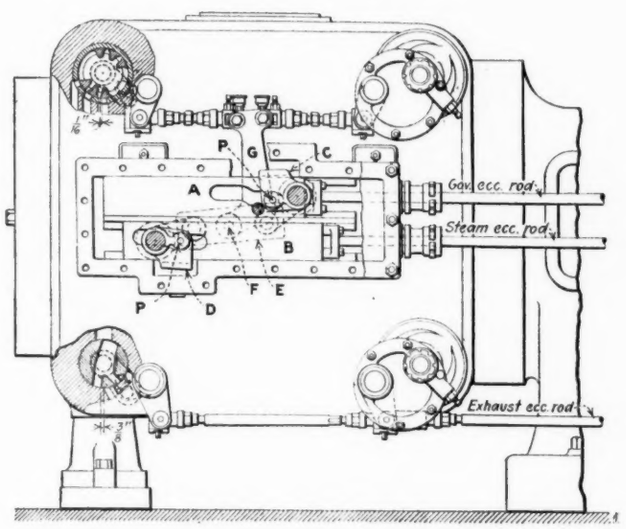


FIG. 4—VIEW OF VALVE GEAR BOX ASSEMBLY

Owing to the high pressure under which these engines operate, it was considered to be highly advisable to have a valve gear that would give movement to both the steam and exhaust valves only at such times as the pressures on these valves was reduced to the lowest practicable point. The complete units were built by the Ridgway Dynamo and Engine Co., Ridgway, Pa.

The Power Plant in a Modern Sugar Refinery

In the Sept. 19 issue the article by Roger B. Stevens, consulting engineer, New York City, under the above title, and describing the plant of the American Sugar Refining Co. of Baltimore, was inadvertently cut in such a way that, in the part discussing the selection of a suitable power system for an industrial plant, the premises upon which the discussion was based, and a part of the discussion itself, were omitted, thus presenting a somewhat different view from that originally written by Mr. Stevens.

Beginning with the second column on page 440, the text should have read as follows:

"Fifteen years ago, the building of an extensive plant for the generation of direct current for industrial use by a single factory, or even for central-station service, would have aroused no great amount of comment, but in the present state of the development of alternating-current equipment, and in view of the very general tendency to operate everything possible with alternating current, a great deal of discussion has been aroused.

"An analysis of present power tendencies and the reason therefor will indicate that this tendency is a natural one, when the change in the method of supplying power to industry that has come about in recent years is taken into consideration.

"Two things primarily have led to the adoption of alternating current in industry. The first, and probably the more important is the introduction and rapid development to an efficient point of the simple, low-priced three-phase squirrel-cage induction motor. The second, which was encouraged and made practicable by the first, is the development of high-tension generating and transmitting equipment, which allows a station generating alternating current to serve widely scattered power-consuming devices economically. This has led to a tendency to do away with the small isolated power plant wherever possible, and to purchase power from large, efficient central stations, rather than to manufacture it. As direct current does not lend itself to the transmission of power in large amounts over long distances, the small user has, in many cases, been forced to the use of alternating current even when he could have procured much better operation in his particular processes by the use of direct current.

"As a result of this evolution the manufacturers of electrical equipment have for some years bent the greater part of their energies to the development of alternating-current equipment, and in many cases the designers of power plants for industrial purposes have apparently forgotten that, under certain conditions, the use of direct current presents real advantages to the power user.

"For these reasons the design of a power plant for service to a single industry presents quite a different problem from that involved in the design of a central station of like capacity.

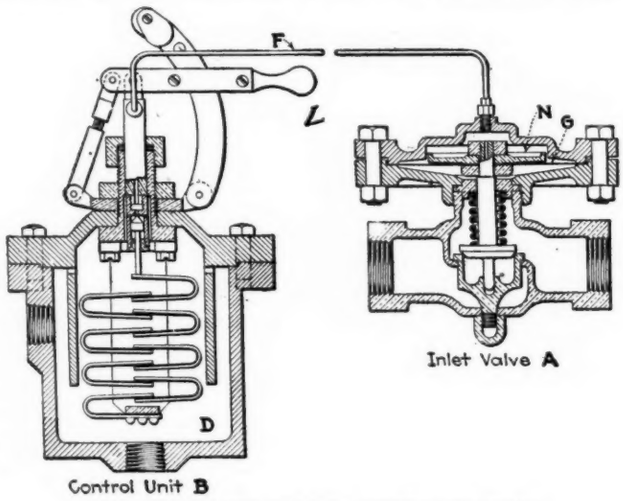
"The designer of the latter finds, when he begins his work, that a number of conditions are already laid down for him and require no discretionary effort on his part. For instance, he may be reasonably well assured when he starts that, after any amount of investigation, he will finally arrive at 60-cycle three-phase alternating current as best suited to all conditions; his generating voltage will be as high as is practicable; his transmission voltage for a given distance and power volume will be established within fairly narrow limits by precedent; and he will, undoubtedly, use turbine-driven alternators with the steam ends operating condensing on superheated steam at as high a pressure as is economical or safe.

"The designer of the power plant that is to serve a single factory or industry can take none of these things for granted. He must begin his work with an exhaustive study of the manufactory that his plant is to serve. He may then find that there is sufficient demand for exhaust steam so that greater over-all economy is to be obtained by operating his prime movers non-condensing. . . ."

From this point (second sentence, second paragraph, second column, page 440) the article as it appeared in the Sept. 19 issue is as it was originally written.—EDITOR.

New Temperature Control Uses Metal Thermostat

The temperature control system here shown is used to govern the flow of heating steam to vulcanizers, dye tubs, mechanical rubber rolls, drying rooms, etc. It depends for operation upon a bi-metallic thermostat instead of upon a volatile liquid. The positive action of



THERMOSTATIC TEMPERATURE CONTROL

the metallic thermostat is said to make for long life and reliability. The system will maintain a temperature within one degree Fahrenheit above or below any desired value; it may be easily set for any desired temperature; it will stand temperatures up to 600 deg. F. without danger of permanent set in the thermostatic element, and it is placed entirely outside of the apparatus to be controlled.

The system operates through changes of steam pressure in the small "feeler" pipe *F* connecting the thermostat chamber *D* with the chamber *N* above the diaphragm *G*. An increase in temperature of the fluid circulating through the control unit *B* causes the inlet valve *A* to close, thus shutting off the heating steam. A drop in temperature allows the valve *A* to open. The working temperature is set manually by operation of the lever *L*.

The device is made by the Files Engineering Co., Inc. (Temperature Control Division), Bridgeport, Conn. All parts are of bronze except the thermostatic chamber and the diaphragm flanges, which are of cast iron.

EDITORIALS

Using Charts in the Power Plant

MANY power plants are operating in a lamentably inefficient way simply because the engineer does not know how to check the operations. If the engineer is to run a plant along approved lines, he must be able to make the necessary calculations to determine the several factors that enter into the operating costs and results. This seems to imply that an engineer must be somewhat of a mathematician. This is true if he intends to make use of formulas in his computations on the plant operations.

This, however, is not necessary. Many, if not all, of the mathematical equations needed around the plant have been put into the form of charts. By using these, the desired information may be obtained with the minimum of effort.

On another page is shown a modification of the Ammonia Heat Chart issued by the Bureau of Standards. The engineer will find, as outlined in the article accompanying the chart, that this chart permits many refrigerating problems to be solved with nothing deeper than arithmetic. The explanation of the uses to which the chart may be put, is lucid. Engineers will do well to put it in their scrapbook or files for future use.

Pooling Their Power Problems

MANY of the French industries, according to a recent report of the French Fuel Commission, have formed local steam users' associations, each having a laboratory and staff of supervising engineers, who analyze the coal, study operating records and render consulting service to the respective manufacturers in matters pertaining to greater fuel economy. Similar organizations are now functioning in Germany with excellent results.

While it is true that Europe, as a result of local and post war conditions, has been faced with the necessity of taking such measures earlier and to a greater extent than has heretofore seemed warranted in this country, nevertheless, the periodic disturbances in coal supply, high prices, and often the necessity of using inferior grades have brought American industries to the point where they could profit by Europe's example.

Many of our large corporations with numerous and extensive plants have long had centralized power supervision within their own organizations, as have also the central-station companies. Furthermore, some industries through committees of their national associations, have attempted to exchange views and experiences in power matters. The latter, however, cannot reach the more intimate problems of every-day operation, and besides, the committee reports are usually presented but once a year.

Local steam users' associations functioning along the lines of those in France and Germany would be especially helpful to the small and medium-sized manufacturer whose business does not warrant the steady employment of a consulting power engineer, but whose share in maintaining such an engineering staff in conjunction with other manufacturers would be nominal and small compared with the possible economies in power generation. Moreover, each would have the benefit of the others' experiences, which gives the plan a distinct advantage over the concern that has its own consultant.

Wasting Our Heritage

THE Fuel Engineering Company of New York has had an analysis made of investigations by its staff of seventy-one industrial and public-utility boiler plants. These plants had in operation at the time of the tests a total of 292 boilers. Almost every type of boiler-plant equipment was included, and all gradations in character and quality of coal were represented. Their average efficiency was 59.8 per cent.

David Brownlie, an English engineer, in a recently issued book upon "Boiler Plant Testing" gives the results of tests, made by the firm with which he is connected, of four hundred different boiler plants.

Two of these, or one-half of one per cent, had efficiencies of eighty per cent or over; sixty-nine, or seventeen and one-half per cent, had efficiencies below fifty per cent. The average efficiency was fifty-eight per cent.

These efficiencies are likely to be above rather than below those of the regular day-in-and-day-out performance, for there is always a tendency for the operating staff to be "on its toes" when a test is being run.

Of the group of seventy-one plants reported by the Fuel Engineering Company seventeen adopted the plan of securing complete and continuous records of power-plant performance under the supervision of that company. They show an average improvement in efficiency of some fifteen per cent. An increase of fifteen over fifty-eight is a gain of more than twenty-five per cent. They had no inherent physical advantages over the others, and the results were achieved with almost no mechanical changes. It was just a case of brain work and interested intelligent attention.

The industries and public utilities of this country use annually some 300,000,000 tons of coal; twenty-five per cent of this is 75,000,000 tons.

Is it worth saving?

An ordinary fireman can handle ten tons of coal a day. Ffteen per cent of it is a ton and a half, worth between ten and fifteen dollars. Half the saving added to the pay of the unskilled labor usually employed would hire a man who could produce the better result, earn his employer one hundred per cent upon the extra salary, relieve the pressure upon the coal market and conserve the most important of our resources.

Experience during the fuel stringency of war times showed how much could be done by a careful use of the imperfect apparatus often at hand. Still more can be done by an intelligent reorganization of the plant, by the use of exhaust steam now wasted, the trapping of drips, the installation of fuel- and labor-saving devices, the use of indicating and recording devices that show

what is being obtained and point the way for improvement in operation.

There is no reason why the average efficiency of the industrial plant should not be over seventy per cent with all that means in lessened cost of production, a better paid and more responsible class of operatives and a lessened drain upon our diminishing fuel supply.

Efficient Operating Methods

IF A plant is to give the best service, it must have reliable equipment, properly installed, maintained and operated. It is generally conceded that poor equipment that is well maintained and operated will in the long run give better service than the best equipment that is neglected after being installed. However, this is not an argument in favor of poor equipment, but it emphasizes the necessity of giving careful consideration to operating and maintenance details of the plant.

In one large plant in this country which is faulty in design in a number of important details, an enviable record of operation has been made. This record is due to the ability and efficiency of those responsible for operation and maintenance. Where the plant has been lacking in design, operating and maintenance methods have been devised that have to a large degree compensated for these defects. Undoubtedly, the cost of operation and maintenance is higher in this station than in a properly designed plant, but to be balanced against this increased cost are reliable service and greater output which, when translated into dollars and cents, make the higher maintenance cost insignificant.

The return on the cost of maintenance has not in general been appreciated as it should be. If equipment could be made one hundred per cent reliable by proper operating methods and maintenance, then no investment in spare equipment would be required. This point has not been reached, either in design or operation, so that in all cases spare capacity is required to insure continuity of service. By proper care in operation this reserve capacity can be materially reduced and yet a higher degree of reliability obtained than in a plant with more spare equipment but not so carefully operated and maintained.

The cost of locating defects and repairing them before they develop into a failure, is generally much less than the cost of repairing a failure. Then there is the increased output of the plant, which is frequently an important item. The extreme of this condition is where a plant is operating on a base load. The load factor in such a plant is high, and when a unit is out of service, it means that practically the entire capacity of this machine is lost and must be replaced by a similar unit or by machines on other parts of the system which may have a much lower efficiency. The output of a thirty thousand kilowatt unit operating at seventy-five per cent load factor is, at one cent per kilowatt-hour, worth two hundred and twenty-five dollars an hour, or over five thousand dollars a day. The cost of having a machine out of service must, therefore, be kept in mind, and this must include cost of repairs, reduction in plant efficiency and loss of capacity.

A carefully trained operating force is just as essential as an efficient inspection and maintenance department. A mistake on the part of an operator may cause serious interruption of service, costly damage to equipment, or in cases of emergency may allow serious damage to occur, which could have been avoided had the proper procedure been followed. A realization of these important facts has led some operating companies not only to select their operators carefully, but also to give them very thorough training in their regular duties as well as what to do in emergency. The effect of this training has resulted in eliminating to a large degree mistakes on the part of the operator, increased the reliability of the plant, and reduced the maintenance charges. Inspection, maintenance and operating methods are frequently considered only as something necessary to keep the plant running, but it has been found that they pay a high rate of return on any investment necessary to carry them into execution.

Public Interest in Combustion

IN TIME of public calamity one can take comfort from the knowledge that people will learn something worth while out of the experience. A big epidemic drives home the importance of sanitary living conditions and expert medical supervision. A "crime wave" creates a demand for an efficient police force. In the same way, coal shortages (whether real or imagined) lead to a greater public recognition of the men who really understand fuels and combustion.

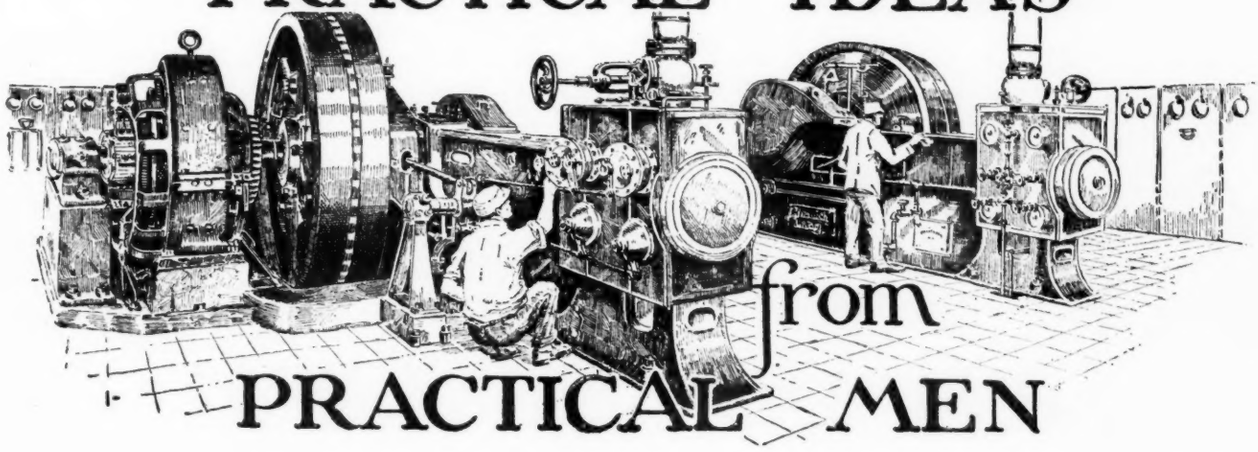
The following extract from an editorial appearing recently in the *New York Times* shows an awakening appreciation of the combustion engineer: ". . . contributes the suggestion that the newly appointed Fuel Administrator [New York State.—*Ed.*] should select as his district deputies men who are competent to do more than attend to the distribution of the available supplies and the keeping of prices within reasonable and decent limits. Needed in these important positions are real combustion engineers, who, besides performing the duties mentioned, also can disseminate through the consuming public exact information about the use of the various kinds and grades, not only of coal, but of the other fuels which in case of necessity can replace in part or whole the accustomed anthracite. Such men will expect to be paid in accordance with their training and abilities, but they will be worth much more than they cost, and as soon as their value is realized nobody will begrudge them what they get."

This looks like the dawn of a new day for the combustion engineer. The general public has heard of him at last and is also coming to realize that the proper utilization of fuel requires something more than a brawny arm to shovel it through the furnace door.

Practically every community of any size has several operating engineers who are practical experts on combustion. When the fuel question becomes a matter of public discussion, these men should take advantage of the general interest to drive home those facts about fuel that people need to know for the common good. The only trouble is that operating engineers as a class are inclined to be overmodest when it comes to writing letters to the newspapers or standing up before supervising committees. Yet it is at times like this that they can be most certain of a good hearing. By taking the initiative now, they can help everybody, including themselves.

Aside from the selection of powdered coal for the latest large central station, it is significant that at least five other large power companies are quietly trying it out on a small scale.

PRACTICAL IDEAS from PRACTICAL MEN



Installing New Liners in a Boiler-Feed Pump

Recently, the liners in the water end of our 7½x4½x 10-in. duplex boiler-feed pump became so corroded and grooved that it was necessary to renew them. While I do not believe we used any new method, perhaps the way that it was done will be of interest to those who have never tried it.

The liners were first ordered by giving the necessary details from the name plate, and were promptly received. The cylinder heads were first removed and the old liners measured to make sure that the new ones were the right size. We then disconnected the discharge and suction pipe and removed the water cap, water-valve plate, old piston packing and rod packing. A bearing was then placed under the yoke so that it would not drop, and the nuts were removed from the studs holding it to the cylinders, and with the aid of a couple of crowbars the water cylinders were moved away from the steam end. As soon as we had moved it the length of the pump stroke, the water pistons hit against the end of the cylinders. Screwing off the jamb nuts until they were flush with the end of the piston rod, the water pistons were loosened from the rod by placing a short piece of shafting against the nuts and hitting it a blow with a sledge hammer. After the water pistons were removed, the cylinders were shoved back until the piston rods were clear. The cylinders were then taken from the pump pit to a more convenient place for working on them.

To groove the liners so that they could be collapsed, we used a boring bar with a tool that was V-shaped on one end and rectangular like a broach on the other. The top end of the broach was ground hollow for clearance so that it would cut when moved in either direction. By holding the boring bar in the hands and first using the V end of the tool, a long groove was made the full length of the liners. When a deep groove was made with the V tool, the bar was turned over and the broach-shaped end used until the liners were cut through. After finishing with the grooving tool a cold chisel was used to curl the liners inward, then a hardwood wedge was driven between the liner and the cylinder wall. This sheared it at the groove and curled it inward the full length. By following up this wedge with one having a sharper angle, the first wedge was removed. Care should be taken to cut the groove through on the inner end or trouble may be experienced in loosening the liner, as it is difficult to make the wedge effective at that point. Only wood should be used for wedges, as metal might scour the cylinder walls and cause trouble in putting in the new liners.

After the old liners were removed, the cylinders were cleaned out and oiled. The oil tends to prevent the liners sticking or being scoured when forced into place. To draw the new liners into the cylinder, we used a long bolt. This was put through the piston-rod hole in one end of the cylinder, and the liner was put over the screw and backed up with a 2-in. pipe flange and the nut. We were then ready to force the liner home. After entering it in the cylinder bore, we turned down the nut until there was a little pressure, and then the liner was carefully squared with the face of the cylinder, after which it was drawn into place. When forcing in a liner, care should be taken to keep it square with the cylinder and a lot of trouble and annoyance will then be avoided.

As the end of the cylinder was beveled, a ball-peened hammer was used to flare the end of the liner slightly. This rounds the end and forces it tightly against the cylinder wall. One of the cylinders was slightly larger than the other, so that the liner could be forced into place with the hands. It was redrawn a few inches and peened carefully so that it required the screw and a wrench to force it into place. Then the end was flared, and no trouble has been experienced with it.

Rockland, Mass. BURTON W. WHEELER.

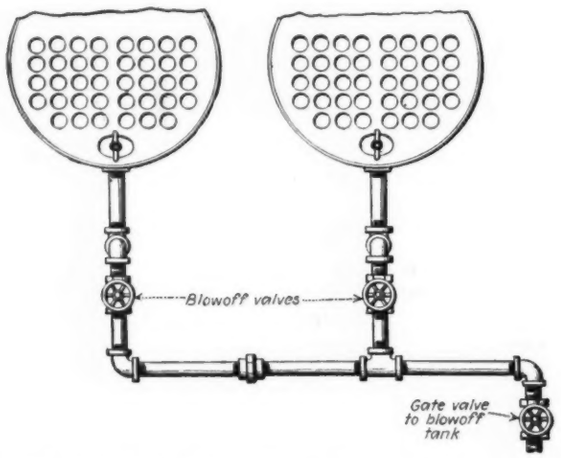
Emergency Feeding of Boiler Through Blowoff Connection

Recently, the fireman of a pair of horizontal return-tubular boilers discovered that the flow of feed water to one of the boilers had suddenly stopped, although the feed to the other remained unimpaired. The feed connections are in the front heads of the boilers. Each branch from the main feed pipe contains a check valve with a gate valve between the check and the boiler connection. A conclusion was quickly arrived at that the trouble was due to the gate having become detached from the stem and this had shut off the supply of water to the boiler.

To repair the valve, it would be necessary to take the boiler out of service. As this would have caused a shut-down of the plant, owing to the other boiler not having

sufficient capacity, it was decided to feed the boiler through the blowoff connection.

The arrangement of the blowoff piping is shown in the illustration. The gate valve on the connection to the blowoff tank was closed and then both blowoff valves were opened. Thus the water was allowed to pass from one boiler to the other. By firing the boilers evenly and



WATER TO THE BOILER WAS REGULATED BY ADJUSTMENT OF BLOW-OFF VALVE

regulating the flow between them by means of the blowoff valves, the water was kept at about the same level in both, and the boiler was kept in service until an opportunity was had for repairing the valve.

St. Louis, Mo. A. J. DIXON.

Letting Well Enough Alone

Many men—some intelligent, others only conceited—are never satisfied to let well enough alone about their engines. They always know better than the builders what will "get the most of the best for the least." It may be only for the purpose of getting a reputation for ability and progress and that sort of thing. It may be because they honestly believe that they can do better than the man who has sold the engine on a guarantee of economy under stated conditions, and naturally had tested that engine, or one like it, under those conditions or comparable ones, so that he could confidently bet on his own horses.

Now between the mossback who never learns anything and the man who is forever trying some new adjustment at the owner's expense and without consulting anyone knowing at least as much as himself, there is really not much to choose. Both kinds are expensive, and the loss from each kind is hard to measure. The one thing that is certain, is that the loss is there. Some engineers live with a monkey wrench in their hands. They would be lost without it; it is their trade mark, their symbol of superiority.

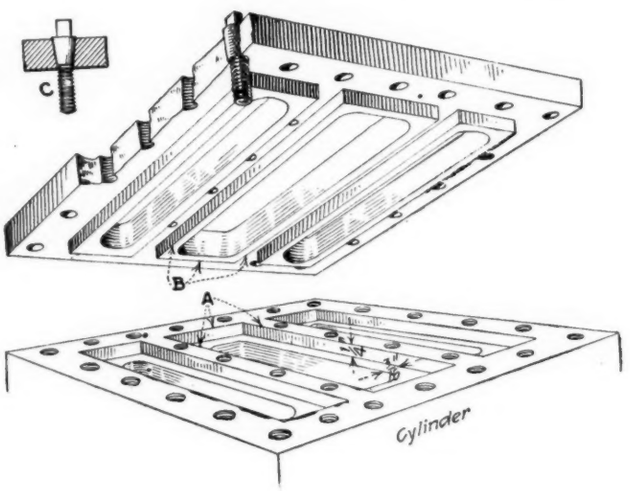
Experiments are all very well under certain conditions. One is, that the experimenter should be certain that there is fault, or loss, or chance for improvement. The next is that he shall be certain just what causes, and what does not cause, the loss, the fault or the chance for betterment. The next is to determine if the experimenter has the mental ability, the training and the equipment, to make the proposed experiments and the resultant changes. And then comes the question of whether it would not cost a dollar and a half to effect a dollar's worth of changes. In these matters, "in the multitude of counselors there is wisdom." Many an engine runner comes down Sunday and attacks the adjustment of the eccentric or takes a little lap off the valve, in the hope of making himself solid with the boss—or with himself. But sometimes, after having made a change that turns out to be undesirable or even harmful, things cannot be brought back to the original condition. For instance, the engineer of my friend's plant took off about three-sixteenths of an inch from the steam lap without altering the position of the eccentric. The result was that he made his admission earlier and his cutoff later, which cut down the economy of the engine. The reason for not changing the eccentric position was that the week before he had altered it by giving more angular advance, and then he found the machine admitting steam sooner and cutting off sooner, while both his release and compression were hastened also. With the slow speed he did not really need so much cushion, although with the earlier cutoff it might have been a slight advantage. So when he took off the lap, he put the eccentric back where it had been.

Experiments are all very well when a record is kept of the previous conditions and of the results of the change; but just "cut-and-try and get-out-of-the-window-if-anything-breaks" never makes either a good engine or a good engineer. Several mills are shut down enough half-hours at a time to make one day in a month, just waiting on the smart engine runner to "take her up a little more" somewhere.

New York City. ROBERT GRIMSHAW.

Fitting a New Valve Face on a Cylinder

It occasionally happens that the slide valve face on a cylinder becomes so badly worn that the fitting of a new valve face is necessary. This is an important



SHOWS METHOD OF FITTING NEW FACE TO CYLINDER

piece of work, and if possible it should be done by a skilled mechanic. The new face must be truly bedded to the cylinder and firmly secured so as to withstand any vibration and friction of the slide valve. The first step is to cut down the face of the cylinder the necessary amount, then carefully bed to a surface plate, using the scraper as a finishing tool and red-lead marking

for indicating the high places. Now take a pair of caliper compasses and mark a line about $\frac{1}{16}$ in. from each edge of the steam and exhaust ports, as indicated by *A*. Center-punch these lines lightly. If no machinery is available, take a side chisel and cut out from the lines a recess about $\frac{1}{4}$ in. deep in the ports. File out the chisel marks and also take off the sharp edges.

The new casting (which should be made in hard brass or gun metal) should now be machined on both faces. Then mark out on one side a true copy of the cylinder steam and exhaust ports and also the lines which form the recesses. Machine out the ports true to the marking off lines, then form nipples around them $\frac{3}{16}$ in. high, working up to lines as at *B*, leaving them a little full so as to allow for fitting. Finish off the outside edges of the new face to dimensions required.

The next operation is fitting the new face to the cylinder. With a little red-lead marking, smear over the cylinder valve face and also the recesses. Take the new valve face and fit it on the cylinder, using a piece of hardwood or lead hammer for the purpose. Keep easing off the high places as indicated by the marking until you are satisfied that the nipples are a good fit. It should be finally finished off as you would bed a slide valve to a surface plate.

Now mark off the new valve face and drill the holes suitable for $\frac{3}{8}$-in. screws and countersink for the heads the full depth of the valve face. Clean off the burs raised by the drilling, then put the new valve face in position on the cylinder. With a scriber mark off the position of the holes to be drilled in the cylinder face. When drilling the holes for the screws the utmost care must be taken to see that the drill is kept central with the marking and that it is at right angles to the valve face. Tapping the holes must also be done with the greatest care; if it is necessary to tap by hand, use the square frequently to make sure that the tap is at right angle to the valve face, for if the holes are tapped out of line, the screws will be forced over to one side of the countersink and be broken off during the process of screwing home.

A templet should now be made for fitting the screws, as shown at *C*. Drill and countersink in the same manner as the holes in the valve face, and machine up the screws, leaving a little draw on the screw head, as shown. The new valve face should then be painted with a mixture of red lead and oil and put in position on the cylinder and secured. If the screws are undercut a little at the bottom of the square, the end should twist off when the screw is forced home; if not, a slight notch with the saw blade will answer the purpose.

Now trim off the heads flush with the valve face and true up the face to a surface plate or to its own slide valve. If this work has been carefully done, a good job should result.

THOMAS W. AIREY.

Gainsborough, England.

"Would-Be" Electrical Engineers

To connect up a direct-current generator correctly is not a difficult task for one who is familiar with the fundamental principles of such a machine, and it is difficult to understand how a man can work a number of years at electrical pursuits or study electrical science enough for him to feel justified in accepting a position with the title of electrical engineer and still be unable to make such a connection; yet there are men who call themselves electricians, and even electrical engineers, who are wholly at sea at such work. The incidents mentioned herein surprised the writer and impressed him with the fact that many men who consider they are proficient in this line are in fact poorly grounded in the A B C's of the particular machines with which they have to do.

The first incident was that of a man who claimed considerable electrical experience. He was left in temporary charge of a gang installing a synchronous motor and motor-generator set. On checking up the work later, it was found that he had both of the direct-current generator armature leads connected to one wire, both of the series-field terminals to another wire, and both of the shunt-field terminals to a third wire. On trying to explain to him how the connections should have been made, he admitted that he had no knowledge at all of how a generator worked and, what was worse, had no realization of his ignorance.

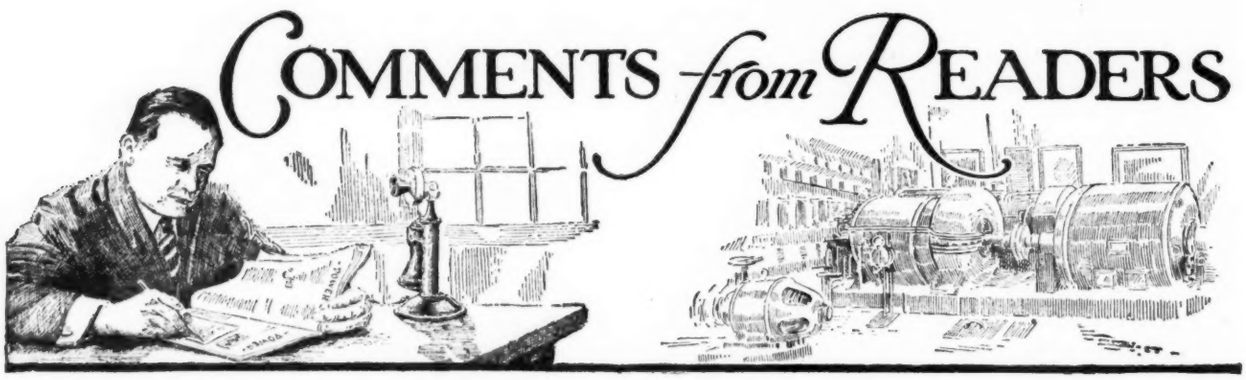
In the second incident a similar installation was being made, except that the generator was belted to the synchronous motor instead of being direct connected to its own motor. This time the generator was connected so that it actually produced current, but while it was rated at 125 volts at full load, it would carry only about one-half load and give 90 volts. The man who had charge of this work writes "Electrical Engineer" after his name, but he was unable to locate the trouble and appealed to the builders of the machine for help. It so happened that the writer had access to the plant and was permitted to make a few tests. He connected a voltmeter across the circuit and with a short piece of No. 6 wire short-circuited the series field coils one at a time. In each case the potential was raised about two volts. Short-circuiting the interpoles caused the potential to fall. These tests did not take fifteen minutes, but they showed conclusively that the series fields were opposing the shunt fields. No changes were permitted, however, until the builder's engineer arrived.

When the engineer arrived, he was informed of the tests that had been made and agreed that the diagnosis was correct, but, before the connections were changed, a compass was held near each pole in turn. Two poles caused a decided deflection of the needle, while the other two caused it to vibrate with uncertainty. From this the conclusion was drawn that only two of the series coils were reversed, and the machine was shut down and preparations made for changing the connections of these two coils. Before this was done, however, the voltmeter was again applied and gave the same readings as before. Reversing the terminals was but a few minutes' work, and after that was done the machine promptly came up to its rated voltage and ampere capacity. The behavior of the compass was explained as being due to the influence of the interpoles, of which there were but two.

G. E. MILES.

El Centro, Calif.

Turbine governor regulation in direct-current units is the drop in speed from the no-load position of the governor to that required for carrying full load. This is usually 2 per cent of the normal speed of the generator. Thus a generator that operates at 3,600 r.p.m. at no load, would have, ordinarily, a speed of 3,528 revolutions at full load. The entire overload position of the valve is usually one-half of the regulation required at the full load, so that 50 per cent overload should ordinarily occur at 3,492 r.p.m.



What Size of Combustion Chamber is Necessary with Fuel-Oil Burning?

There has been considerable discussion recently on the different problems met with in fuel-oil burning, but so far no one has given any information on the size of combustion chamber required per pound of fuel burned. For instance, take a Stirling boiler of 5,000 sq.ft. heating surface operating at 140 per cent of rating and producing 21,000 lb. of steam per hour on 1,500 lb. of oil with just sufficient draft to maintain 13 per cent CO_2. Operating under these conditions, what size of combustion chamber would be considered good practice?

I would like to see some comment from readers of *Power* who have had experience along this line.

Lincoln, Neb. M. DAVIES.

Placing Lubricator on Main Steam Line

With reference to the inquiry by A. C. B. in the Sept. 5 issue as to the advisability of installing a lubricator in the main steam line, I agree with the answer given, that it would not be advisable to install this lubricator where there will be danger of the oil attacking the gaskets, but we have in one of our plants an interesting installation of this nature.

Our boilers are equipped with underfeed stokers on which each ram is driven by a separate steam cylinder. The practice was, formerly, to install a small lubricator for each stoker, but we had trouble with them continually on account of the oil not atomizing properly. We finally concluded the trouble to be due to a low steam velocity. Accordingly, a larger lubricator was installed on the steam line ahead of all steam connections to the stokers, and we found that this corrected the trouble. The stokers have been operating under these conditions for nearly a year, and we have had no trouble with pistons sticking in the cylinders.

E. W. BRYAN, Asst. Supt. Steam Plants,
Atlanta, Ga. Georgia Railway & Power Co.

Motor Trouble from Flexibility of Mounting

The answer given to the inquiry by R.S.A. in the Aug. 22 issue, as to the cause of motors losing the binding wire, covers this question quite fully, but I would like to add further to it:

Flexibility of mounting between the motor and the driven gear should not, in my opinion, cause defection of the shaft sufficient to strike the polepiece, but it may cause excessive wear on the teeth of the gear and possible stripping. It will also cause more wear on the bearings than if the gears are securely held in mesh. Motors that are geared to a load and set on separate foundations are usually not as rigid as when they are made a part of the machine they drive.

It sometimes happens that the bore in a new gear is too large, and when keyed up, it is thrown out of truth. This makes the gears mesh too tightly at one point and may cause a deflection of the shaft.

In my opinion the most probable cause of this trouble is that the motor is fitted with too small a shaft for the service under which it is operating, and if this were replaced with one of larger size, the trouble would disappear. R. A. CULTRA.

Cambridge, Mass.

Should Boiler Code Bar Emergency Fleet Boilers from Land Installations?

In the letters by F. W. Dean in the Aug. 8 issue and by Joseph Breslove in the Aug. 29 issue, the objections raised to the ruling of the boiler commissioner of Pennsylvania, in which he decided that boilers built for the United States Shipping Board are not eligible for installation in the State of Pennsylvania, undoubtedly have a worthy objective, but upon referring to the Code of Boiler Rules under which he operates, I find that he had no other course open unless he openly violated the rules made a part of that code by state laws.

The preface of the Pennsylvania code states that all boilers within the confines of the state, except railway and those subject to federal inspection, shall come under its jurisdiction. In view of this statement the commissioner is forced to act upon any boiler formerly subject to federal inspection, which is brought into the state. Again, a boiler constructed along the lines of those made for the United States Shipping Board, is barred from the State of Pennslyvania by two separate sections of this code.

These boilers undoubtedly have many good points. In fact, they have proved this in numerous installations, but under the existing rules no provision has been made for their entry into this state.

The commissioners of several states are unable to give definite information as to whether or not the A.S.M.E. Code governs installations in their state or if a state law takes preference in certain cases. Any code is given two public hearings before becoming a part of the state law and is subject to revision at that time. Interested engineers will do well to attend these hearings in order to prevent possible disappointment in regard to some proposed installation. H. N. HITE.

Scranton, Pa.

Where Should the Purge Cock Be Located?

In *Power*, Sept. 5, R. G. Summers shows a sketch of the ammonia condenser in his refrigerating plant and asks whether the purge cock is correctly located. The sketch, which is here shown as Fig. 1, indicates a counterflow double-pipe condenser with downward flow

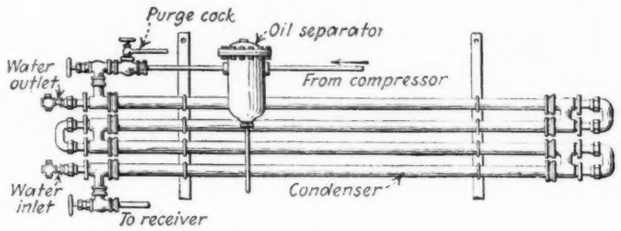


FIG. 1—ORIGINAL PURGE CONNECTION

of ammonia and upward flow of cooling water. The purge cock is shown at the top of the condenser, where the hot gas is entering from the compressor.

When the compressor is running, the gas passing this purge cock consists of pure superheated ammonia vapor. Why pure? Because, normally, only liquid ammonia goes through the expansion valve, and the evaporation of that liquid can result in nothing else than pure ammonia vapor.

For this reason a purge connection located as this one is, must be used when the compressor is shut down, so that the foreign gas can reach it, and even then its use will not be economical, because a large volume of ammonia vapor must pass out to make way for the non-condensible gas. This is confirmed by Mr. Summers' statement that in purging his single-stand condenser it was necessary to renew the water in the pail three or four times.

The coldest gas in this condenser is unquestionably at the bottom, where the cold water enters and where the liquid ammonia leaves. Gravity, the sweeping action of the moving vapor and the progressive liquefaction of the ammonia all tend to carry the non-condensible gas to the bottom of the condenser, and the question arises, is this where the foreign gas collects, or is it carried on into the liquid receiver? To answer this question we must know whether the receiver is in a cold or a warm place.

If the liquid receiver is in a cold place, so that the liquid ammonia becomes colder than when it left the condenser, then condensation of vapor will take place in the receiver. To refill the space, more vapor is drawn into the receiver from the condenser. With this vapor is carried the foreign gas, which lodges in the receiver, since it cannot condense and can go no farther.

Therefore, when the liquid receiver is colder than the gases and vapor in the condenser, the purge cock should be located on the receiver. In this case purging can be done most effectively while the machine is running, using a very small opening of the purge cock.

If the liquid receiver is in a warm place, where the liquid is slightly warmed after it enters the receiver—a common but undesirable condition—there will be a slight re-evaporation in the receiver, causing ammonia vapor to pass back through the liquid pipe to the condenser. This flow prevents the foreign gases from reaching the receiver.

In this type of condenser, when the receiver is warm, the foreign gases collect at the bottom of the condenser, and that is the place for the purge cock. If it is so located, purging can best be done while the machine is in operation. Fig. 2 shows a desirable arrangement for the purge connection for this type of condenser, with a warm receiver. At the bottom of the condenser, just beyond the ammonia valve, is inserted a tee with a pipe riser, at the top of which is the purge cock. The size of this riser is sufficient to permit it to act as a separator, thereby separating liquid ammonia from the rising gas. This purge arrangement is still further improved if the riser is cooled by the coldest available cooling water.

The answers just given agree with the criterion stated in the article in *Power*, July 25, to which Mr. Summers refers, namely: "The foreign gases should be withdrawn from that point in the condensing system where the temperature of the gases and vapors is lowest . . . may not be in the condenser at all, but in the

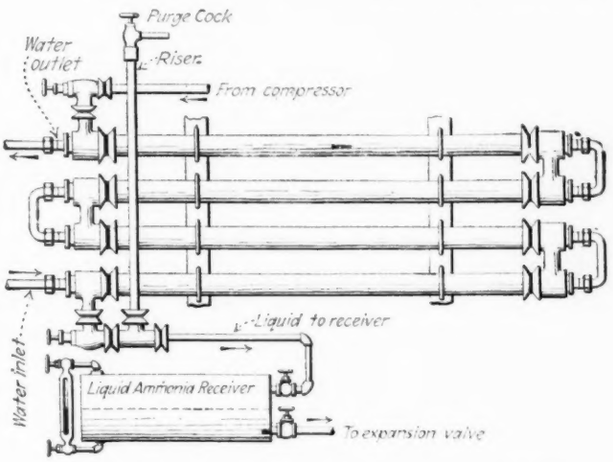


FIG. 2—SUGGESTION FOR LOCATION OF PURGE

ammonia receiver or elsewhere." I have failed to find a case where this criterion does not hold good. It may not be the place where the cooling water is coldest, and there may be dispute as to where the gases and vapors are coldest, but if that place can be found, that is the right location for the purge cock.

Brooklyn, N. Y. THOMAS M. GUNN.

How Can Lap-Seam Cracks Be Detected in Small Horizontal Boilers?

There has been considerable discussion recently on the dangerous conditions existing due to cracks in the lap seams of horizontal tubular boilers. The type of crack referred to is found only in boilers with lap seams and cannot be detected from the outside or external inspection of the boiler, for the crack takes place on the inside of the shell. There is no way to inspect for such cracks in boilers that are less than 40 in. in diameter, or in internally fired boilers less than 48 in. in diameter.

The Boiler Code states that boilers of this type over 40 in. in diameter shall be provided with a manhole above and below the tubes. Therefore, to eliminate the dangers due to cracks in boilers below this size, some means must be provided whereby the lap seam can be inspected. I would like to see some readers of *Power* express their opinions on this subject.

Olean, N. Y. CHARLES W. CARTER.

QUESTIONS AND ANSWERS

Why More Lap on Head End

On a single-valve engine, why is more steam lap of the valve required for the head end than for the crank end? R. W.

On account of the angularity of the connecting rod there is a larger number of degrees of rotation of the crankshaft for any fraction of stroke of the piston from the crank end than from the head end of the cylinder. With the same lap for each end of the valve the number of degrees of angular movement of the crank and eccentric necessary to accomplish cutoff would occur later in a stroke from the head end than in a stroke from the crank end, and to more nearly equalize the cutoffs, more valve lap is required for the head end.

Lead of Greater Importance than Equal Cutoffs

In setting a D-slide valve, is it of greater importance to obtain good leads or to equalize the cutoffs of opposite ends? E. E. R.

The economy of the engine is not materially affected by a considerable variation of the point of cutoff, but it is desirable to have sufficient lead to fill the steam passages with steam by the time the piston is ready to start out on its stroke, and sometimes also for smoother running to cushion the piston over the center on engines where there is little compression of the exhaust. There is considerable lowering of the pressure when the steam enters the cylinder and comes in contact with surfaces that have previously been cooled by the exhaust of lower temperature, and, if admission at full pressure is delayed, the re-heating of the cylinder with reduction of pressure is extended to the period of admission.

Efficiency of Boiler

The analysis of coal used in a boiler trial was as follows: Carbon, 80 per cent; hydrogen, 5 per cent; oxygen, 4 per cent; nitrogen, 2 per cent, ash, 9 per cent. The amount of coal used per hour was 4,000 lb., and 25,000 lb. of feed water, at 100 deg. F., was evaporated per hour into steam at 100 lb. absolute pressure. What was the efficiency of the boiler? E. S.

From the data given, and as generally understood, the efficiency of the boiler is assumed to be the combined efficiency of the boiler, furnace and grate, and is the heat absorbed per pound of the fuel divided by the heat per pound of the fuel.

With evaporation at the pressure of 100 lb. per sq.in. absolute, each pound of steam generated, according to Marks and Davis steam tables, would contain 1,186.3 B.t.u. above 32 deg. F., and with feed water at 100 deg. F. each pound of the feed water for conversion into steam would have to receive (1,186.3 — (100 — 32) = 1,118.3 B.t.u.

As under the conditions stated there was an evaporation of 25,000 lb. of feed water for use of 4,000 lb. of coal, there was 25,000 ÷ 4,000 = 6.25 lb. of water evaporated per pound of coal, and the heat absorbed amounted to 1,118.3 × 6.25 = 6,989.4 B.t.u. per pound of coal.

The heat of the coal may be calculated by Dulong's formula:

$$B.t.u.\ per\ lb. = 14{,}500\,C + 62{,}100\left(H - \frac{O}{8}\right) + 4{,}000\,S$$

in which C, H, O and S are respectively the weights of carbon, hydrogen and sulphur present in one pound of the fuel. As the coal analysis gave $C = 0.8$ lb., $H = 0.05$ lb. and $O = 0.04$ lb. per pound of the coal, by substitution

B.t.u. per lb. of the coal

$$= 14{,}500 \times 0.8 + 62{,}100\left(0.05 - \frac{0.04}{8}\right)$$

$$= 14{,}394.5\ B.t.u.$$

and the combined efficiency of boiler, furnace and grate

$$= \frac{6{,}989\,4}{14{,}394.5} = 0.485 \text{ or } 48.5 \text{ per cent.}$$

Cooling Water by Pumping Through Submerged Coil

We are intending to submerge a 2-in. pipe coil 1,440 ft. long in a reservoir that holds 500,000 gal. of water. Water at 120 deg. F. is to be pumped through this coil at the rate of 70 gal. per min. The temperature of the water in the reservoir is 56 deg. F., and 1,300 gal. of water passes through the reservoir per minute. To what temperature may we expect to cool the water passed through the coil? D. M. W.

The rate of cooling will depend largely on the character of circulation of the reservoir water over the exterior of the 2-in. pipe coil. For instance, if the coil is submerged in the swiftest current of water passing through the reservoir, the cooling will be considerably faster and consequently a lower temperature will be obtained than if the coil were submerged in a part of the reservoir where the water is nearly stagnant.

Water pumped through a continuous or single 2-in. pipe coil at the rate of 70 gal. (583 lb.) per min. would have a velocity of approximately 458 ft. per min. and would pass through 1,440 ft. of pipe in 3.14 min. For a velocity of 50 ft. per min. of the reservoir water surrounding the coil, there would be transfer of about 10 B.t.u. per hour, or 0.166 B.t.u. per minute per square foot of surface per degree mean difference of temperature.

Calling the final temperature t, the mean temperature would be $(120 + t) \div 2$, and the mean temperature dif-

ference would be $[(120 + t) \div 2] - 56$. The cooling surface of 1,440 lin.ft. of 2 in. pipe would be 1,440 ÷ 1.61 = about 900 sq.ft., and the B.t.u. transferred in 3.14 min. required for the water to traverse the full length of the coil would be

$$3.14 \times 0.166 \times 900 \left(\frac{120 + t}{2} - 56\right) = (120 - t)\ 583$$

for which the final temperature t = 83 deg. F.

Actual Ratio of Expansion

In a compound engine with the high-pressure cylinder 14 in. in diameter and the low-pressure cylinder 30 in. in diameter, each with 36-in. stroke, the clearance is 5 per cent in each cylinder. If cutoff occurs at one-third stroke, what is the total ratio of expansion by volume? P. D. C.

With 5 per cent clearance and cutoff in the high-pressure cylinder at one-third stroke, the number of cubic inches volume of steam at cutoff would be $(0.5 + \frac{1}{3})14^2 \times 0.7854 \times 36$.

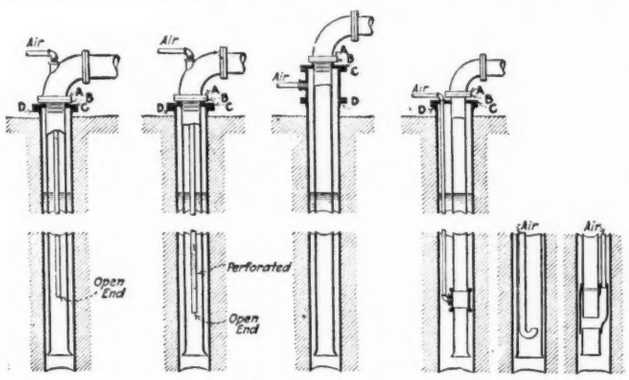
After complete expansion in the low-pressure cylinder the volume of the steam would be $(0.05 + 1)30^2 \times 0.7854 \times 36$. Hence the ratio of the expansion would be

$$\frac{(0.05 + 1)30^2 \times 0.7854 \times 36}{(0.05 + \frac{1}{3})14^2 \times 0.7854 \times 36} = \frac{1.05 \times 30^2}{(0.05 + \frac{1}{3})14^2} = 12.57$$

Piping Systems for Air-Lift Pumps

What is the method of piping the air head and foot pieces of an air-lift pump for raising water from a cased deep well? R. L. G.

Any system that finely divides the air volume and provides a free passage for the mixed air and water



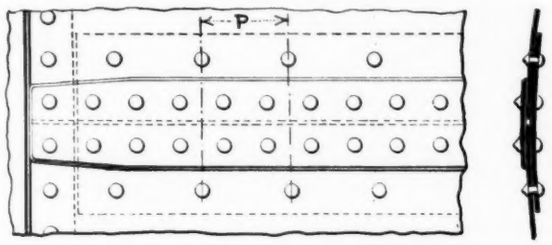
PIPING SYSTEMS FOR AIR LIFTS

will be found satisfactory. The figure illustrates a number of systems of piping most frequently installed, the letters *A*, *B*, *C* and *D* referring to parts common to each system. In addition to those illustrated, there are several manufactured systems having specially designed head and foot pieces. In some of these dependence is placed on refined forms of nozzles and deflector tubes for obtaining the superior efficiency claimed for them.

Efficiency of Butt and Double-Strap Joint, Double-Riveted

What is the efficiency of a butt and double-strap joint, double-riveted, in which the tensile strength of plate is 55,000 lb. per sq.in.; thickness of plate, $\frac{3}{8}$ in.; thickness of butt straps, $\frac{5}{16}$ in.; pitch of rivets in outer rows, $4\frac{7}{8}$ in.; pitch of rivets in inner rows, $2\frac{7}{16}$ in.; diameter of rivets after driving, $\frac{7}{8}$ in.; shearing strength of rivets in single shear, 44,000 lb. per sq.in.; shearing strength in double shear, 88,000 lb. per sq.in., and crushing strength of material 95,000 lb. per sq.in.? W. L. C.

The efficiency of the joint would be the least strength per unit of pitch, *P* in the figure, for any method of



BUTT AND DOUBLE-STRAP JOINT DOUBLE RIVETED

failure of the joint, divided by the strength of solid plate for the same length of joint.

Having a tensile strength of plate = 55,000 per sq.in. and thickness of plate = $\frac{3}{8}$ in. = 0.375 in.,

(1) The strength of solid plate per unit of pitch *P*, $4\frac{7}{8}$ = 4.875 in., would be

$$4.875 \times 0.375 \times 55{,}000 = 100{,}547 \text{ lb.}$$

With thickness of butt straps $\frac{5}{16}$ = 0.3125 in.; cross-sectional area of rivets $\frac{7}{8}$ = 0.875 in. diameter = 0.6013 sq.in.; strength of rivets in single shear = 44,000 lb. per sq.in.; strength of rivets in double shear = 88,000 lb. per sq.in.; and crushing strength of the material 95,000 lb. per sq.in., the strength of joint per unit of pitch would depend on one of the following considerations:

(2) Strength of plate between rivet holes in the outer row =

$$(4.875 - 0.875)\ 0.375 \times 55{,}000 = 82{,}500 \text{ lb.}$$

(3) Shearing strength of two rivets in double shear, plus the shearing strength of one rivet in single shear =

$$2 \times 88{,}000 \times 0.6013 + 1 \times 44{,}000 \times 0.6013 = 132{,}286 \text{ lb.}$$

(4) Strength of plate between rivet holes in the second row, plus the shearing strength of one rivet in single shear in the outer row =

$$(4.875 - 2 \times 0.875)\ 0.375 \times 55{,}000 + 1 \times 44{,}000 \times 0.6013 = 90{,}910 \text{ lb.}$$

(5) Strength of plate between rivet holes in the second row, plus the crushing strength of butt strap in front of one rivet in the outer row =

$$(4.875 - 2 \times 0.875)\ 0.375 \times 55{,}000 + 0.875 \times 0.3125 \times 95{,}000 = 90{,}429 \text{ lb.}$$

(6) Crushing strength of plate in front of two rivets, plus the crushing strength of butt strap in front of one rivet =

$$2 \times 0.875 \times 0.375 \times 95{,}000 + 0.875 \times 0.3125 \times 95{,}000 = 88{,}320 \text{ lb.}$$

(7) Crushing strength of plate in front of two rivets, plus the shearing strength of one rivet in single shear =

$$2 \times 0.875 \times 0.375 \times 95{,}000 + 1 \times 44{,}000 \times 0.6013 = 88{,}800 \text{ lb.}$$

The least strength would be obtained by consideration (2), namely 82,500 lb. per unit of pitch, and the efficiency of joint is 82,500 ÷ 100,547 = 0.82 or 82 per cent.

Analyzing Turbine Vibration With the Aid of the Vibrograph

IN THIS country an inspection with the application of a few simple tests, reinforced by experienced judgment would ordinarily be employed in preference to involved methods of determining vibration troubles. An interesting analytical method of locating the cause of an especially severe case of vibration, however, which had rendered the

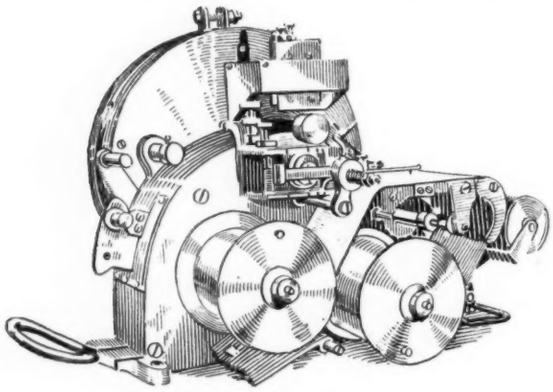


FIG. 1—THE VIBROGRAPH

operation of a 10,000-kw. turbine, running at 3,000 r.p.m., unquestionably dangerous, is described in the *Zeitschrift Des Vereines Deutscher Ingenieure*, May 6, 1922, by Dr. Jos. Geiger. Following a careful examination of the machine, the author decided to investigate the causes with the aid of a vibrograph.

This instrument had been developed principally to detect vibration in high-speed Deisel-engine bearings. The fundamental principle is identical with that of the seismograph. The instrument serves to measure the relative movement of the object in vibration, with respect to a stationary mass. The relative motion is recorded on a paper strip, which is advanced on a drum turned by clockwork.

Referring to Fig. 1, the instrument is provided with a substantial bearing base, which is placed upon or bolted to the turbine part under consideration. A heavy weight *d*, Fig. 2, attached to an arm and hub, may be swung around a stationary hollow spindle *b;* it is connected to the spindle by means of a spiral spring *e*. A protecting casing *c*, to

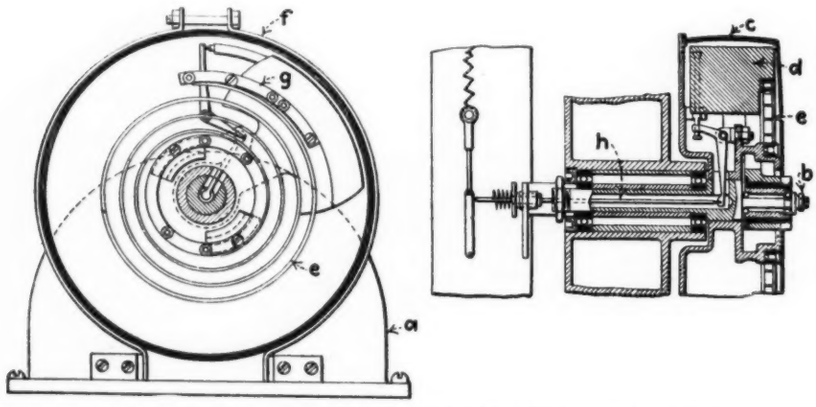


FIG. 2—ARRANGEMENT OF THE RECORDING MECHANISM

which the spring adjustment is attached, may be swung about the hub. The weight and casing may be turned through any angle and locked in the desired position by tightening the band *f*. The relative movements between the weight *d* and its casing are tangential to the spindle *b*. They are first transformed to radial and then to axial, and are finally transmitted to the pencil through the hollow spindle by the rod or link *h*.

When the center line of the weight is held in a vertical plane, below the spindle, the instrument will record horizontal vibration. If it is raised into a horizontal plane, vertical vibration will be recorded. The adjustable clamping ring *g* permits the proper spring tension to be maintained in

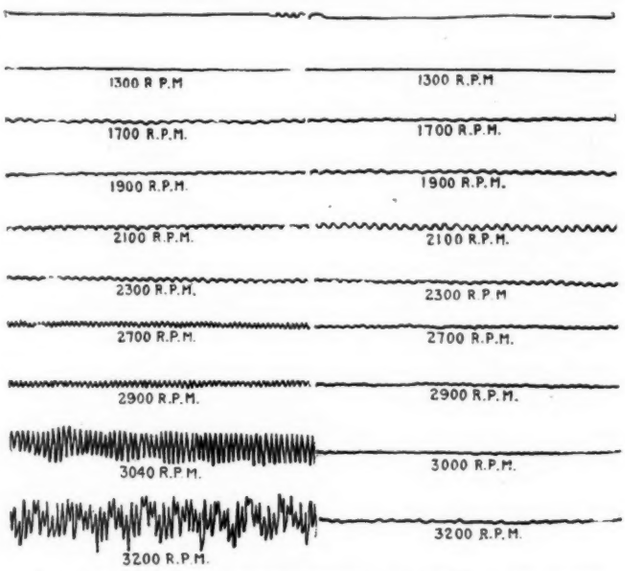


FIG. 3—RECORDED VIBRATIONS AT LEFT AND RIGHT SHOW OUTBOARD BEARING BEFORE AND AFTER REINFORCING THE FOUNDATION

any position of the weight. The vibration occurring in any plane other than the horizontal or vertical may be similarly recorded.

The vibrograph weighs about 14½ lb. and occupies a space equal to that of an 8-in. cube. The range begins with vibrations that are barely perceptible to the touch, and extends to oscillatory movements of over ⅜ in., with a frequency as high as 15,000 per minute.

Following several trials, it was decided to place the vibrograph on three main bearings to measure the vertical vibrations. It was noted that the outboard generator bearing chattered violently, which seemed to be caused by a force in an axial direction. As the turbine ran without end thrust, this condition puzzled the investigators until it was discovered that the bearing had not been set directly above the neutral axis of the cross-beam that supported it. The vertical forces therefore exerted a turning effect about the neutral axis, which resolved itself into a marked axial vibration. Application of a torsion-meter confirmed this deduction.

The vibration was aggravated by a condition of resonance, in that vibratory effect corresponded with the natural frequency of vibration of this bearing. The effect on the other two bearings was not nearly as great. Reference to Fig. 3, left hand side, will show evidence of this condition of resonance at 3,040 r.p.m. of outboard bearing.

Although the apparent reason for the behavior of the outboard bearing had been found, it was still not quite clear as to whether all the trouble could be attributed to this cause. The first critical speed based on a former observation was close to 1,650 r.p.m., which was again confirmed by the vibrograph. The second critical speed, as stated by

FIG. 4—VIBRATION RECORDED ON THE CROSSBEAM ITSELF, AFTER AND BEFORE REPAIRS

the builders, should not have occurred until the speed had well exceeded 3,000 r.p.m.

Accordingly, it was decided to measure the natural frequency of vibration of the foundation, turbine parts and especially that of the shaft, by applying the vibrograph.

The instrument was placed on the crossbeam near the upper bearing, and the pencil was allowed to draw a straight line in the zero position. A 143-lb. weight was suddenly dropped from a height of 27½ in. and a record of the shock and resulting vibration taken. This is shown in Fig. 4.

Other parts of the foundation and the turbine casing were then similarly tested.

To determine the natural frequency of the shaft vibration necessitated a change in the vibrograph. The weight, casing and hollow spindle were removed and replaced by a bell crank *l* and contact rod mounted on an adjustable support *k*, which may be locked at any angle by tightening thumb nut *n*, Fig. 5.

The instrument was bolted to the lower casing, and the contact applied to the periphery of the shroud ring of a rotor wheel, as diagrammatically shown in Fig. 6.

The vibrograph was then permitted to draw a straight line as before. The shaft was then struck a sharp blow with a piece of gas pipe and the resulting vibration recorded.

To determine the minimum natural frequency of a two-bearing shaft, the vibrograph should be mounted at a point

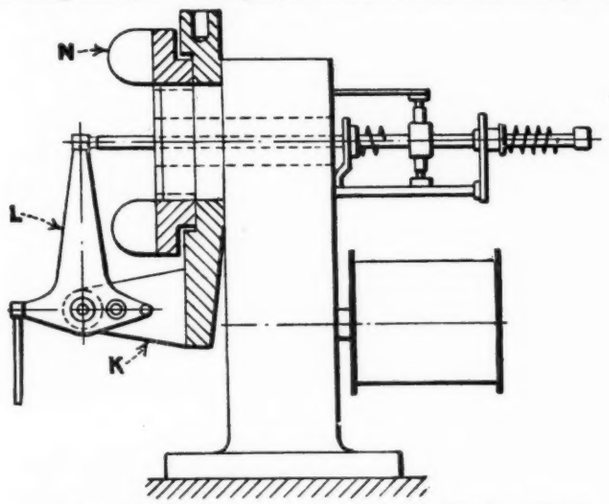


FIG. 5—MEASURING CRITICAL VIBRATION PERIOD WHEN SHUT DOWN

The weight and casing were removed, and pointer connected directly to the rotor, which vibrated when struck.

midway between the two bearings, and the blow struck near this point. To record the second natural frequency, the vibrograph should be placed, and the blow struck, at a point about one-fourth the distance between the bearings.

Since the critical speed is numerically equal to the natural frequency of vibration, this method offers a most convenient way of obtaining the critical speed without calculation.

The application of these tests to the turbine under investigation failed to show that the critical speed occurred at or near 3,000 r.p.m. It was observed that at times the chattering at the generator outboard bearing was well within safe limits at 3,000 r.p.m. and at other times not. Sometimes dangerous chattering would begin at 2,800 r.p.m. and at another time it would not appear until after the speed had increased to 3,100 r.p.m.

A careful analysis of the operating conditions offered the following explanation of this behavior. It was found that the air discharged from the generator was very warm, and that it was directed across the underside of the crossbeam

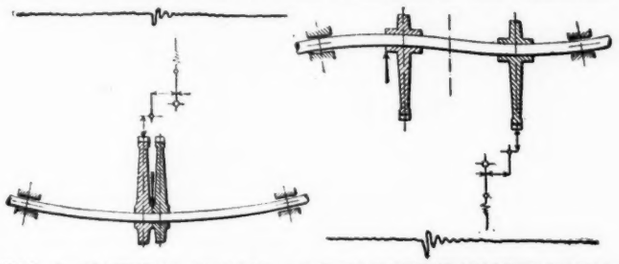


FIG. 6—NATURAL PERIOD AT TWO POINTS IN THE ROTOR

and across the inner side of the columns that supported it. This caused the columns to elongate. At the same time the expansion of the turbine shaft increased the load on the beam. Consequently, the frequency of its vibration decreased, causing the dangerous chattering to appear at the lower speed after the machine had become warm under load. Subsequent observation and tests confirmed this condition.

Reinforcement of the crossbeam and columns fully corrected the trouble. No objectionable chattering or vibration took place during the following six months with the turbine in practically continuous operation. Comparison of the records introduced in Fig. 3 will show the decided improvement.

Additional records of the vertical vibration of the shaft were made, first by suspending the vibrograph, equipped with a special roller contact, from an overhead crane and later by supporting it on the bearing cover. The first application recorded the true vibration of the shaft in a definite direction, whereas the second recorded the relative vibration with respect to the turbine cover.

A study of the records will show that none were obtained that were purely sinuous in character, as would be theoret-

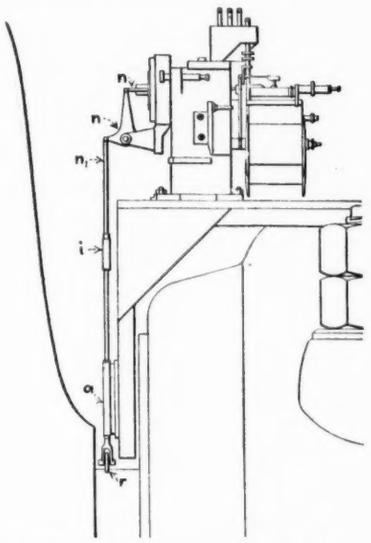


FIG. 7—MEASURING VIBRATION OF SHAFT "r" IN A VERTICAL DIRECTION

ically presumed. In some cases they show that the extent of the pencil travel is doubled periodically, while others show irregular periods of reduced frequency. Increased vibration does not occur only at the theoretical critical speed, but takes place also at other speeds, a fact that is of great importance.

Internal-Combustion Engines for Power Generation in Steel Plants*

By D. M. Petty
Electrical Engineer, Bethlehem Steel Co.

The gas- and oil-engine equipment at the Lehigh Plant of the Bethlehem Steel Co., consists of six 3,000-kw. and one 4,000-kw. twin-tandem double-acting blast-furnace gas engines and a 1,500-kw. two-stroke-cycle Diesel engine.

The floor space occupied is 68 ft. long and 37 ft. 6 in. wide. The distance between center lines of the 3,000-kw. gas-engine cylinders is 27 ft. 8 in. The crankshaft carries a very heavy cast-steel flywheel made in two parts, the diameter being 28 ft. and the weight 130 tons. In this particular size the cylinder, which is 47 in. in diameter, has a 60-in. stroke and is usually made in two pieces; however, in this size as well as in similar smallar sizes, one-piece cylinders have been found entirely satisfactory.

Steel rather than cast iron is employed for the cylinders and pistons, because in order to maintain the same factor of safety the wall of the cast-iron cylinder must be much thicker than if cast steel be used. The cast iron wall must, on account of strength, be made of a thickness so great that it cannot transmit the requisite heat per unit of surface. The consequent difference in temperature between inner and outer surfaces of wall induces heat fatigue and consequent cracks when engines are steadily operated at full load. A fractured cast-iron cylinder cannot be repaired by welding. On the other hand, a cast-steel cylinder seldom cracks, and if it does, it can be electric-welded without any difficulty. Steel cylinders have operated continuously thirteen years and are still perfectly good.

The speed of this engine is controlled by a spring-weighted governor which operates an oil relay. This relay provides ample power for moving the valves, no matter whether they are clean or dirty, and is an important item in the satisfactory operation of any engine used in the generation of power.

An automatic gas-pressure regulator is located just ahead of the inlet valves and maintains a constant gas pressure of 2 in. at the inlet valve. The air mixture is adjustable, but is maintained constant throughout any range of load from zero to maximum unless adjusted by hand, the power output of the engine being governed by throttling the mixture of gas and air rather than by adjusting its richness. The maximum pressure in the cylinder after explosion is 275 lb.

A gas engine of this size can be bought today, f.o.b. factory, for $230,000, making the cost of the engine $57.50 per kilowatt. Table I shows the installed cost per kilowatt of a gas power plant made up of three or more 4,000-kw. units as described herein:

TABLE I—SHOWING INSTALLED COST PER KILOWATT CAPACITY OF A GAS-ENGINE POWER STATION IN 4,000-KW. UNITS

	Cost per Kilowatt of Installed Capacity
Building, modern construction, brick and steel, tile floors, and crane, including exhaust tunnel and stacks	$7.50 to $15.00
Foundations for engines, including excavation at $15 per cu. yd.	4.50 to 9.00
Engines, including all piping, painting, etc., ready to run	60.00 to 75.00
Gas-cleaning apparatus	6.00 to 8.00
Generators, switchboard, exciters, oil switches for 6,600 volts	13.00 to 20.00
Miscellaneous expenses	10.00 to 15.00
Total	$101.00 to $162.00
Average cost per kilowatt	$132.00

The subject of gas engines should not be passed without calling attention to at least one of the points for future improvements in net operating efficiency; namely, the utilization of the heat contained in the exhaust gases. Reclaiming this energy is somewhat similar to the application of condensers to the steam turbine. This field is merely scratched today in a few plants where feed water for boilers is heated in a small way. The water enters the piston rod at about 100 deg. F. and comes out at 130 deg. F., passes to the feed water, where it is raised to 170 deg. F. Much greater economies may be obtained by placing a large boiler or water heater so that the exhaust gases may pass through it on its way to the stack.

One very great possibility lies in the heating of water which may in turn be circulated in near-by buildings and used for heating purposes. In Germany steam boilers have been used, one showing 2.2 lb. steam for each kilowatt-hour generated by the engine. Large boilers will, of course, produce more steam. It has been conservatively estimated that the total efficiency of the gas engine may be increased easily 30 per cent by the use of exhaust gas boilers.

The reason such boilers have not come into more general use is that the efficiency of the gas engine is now high and the cost of coal not sufficiently high to urge the development of this line of apparatus.

Table II shows the operating cost of the gas engines (six 3,000-kw. units and one 4,000-kw. unit) in the Lehigh plant.

TABLE II—COST OF OPERATION

	Cost per Kw.-Hr.
Fuel—1,443,288,000 cu.ft., average B.t.u. value 9a per cu.ft., at 0.0094 per 1,000 cu.ft.	$0.00158
Labor—Including switchboard operators, engineers, oilers, superintendents, etc.	0.00030
Repairs—Including renewals, tools miscellaneous supplies and labor in repairs	0.00033
Water for cooling—Oil, waste and packing, including cooling pond expenses	0.00021
Gas Cleaning—Including water, labor, repairs and power.	0.00037
Total operating cost	$0.00279
Heating feed water with exhaust gases (installed on four engines only) credit	0.00033
Net operating cost	$0.00246

In the matter of operating costs one of the principal items in the past has been the renewal of worn steel parts, such as pistons, cylinders, piston rods, etc. This item has been very materially reduced by the careful application of electric welding. Formerly, when the grooves of the piston became worn to such an extent as to cause excessive leakage by the piston ring, all that could be done was to remachine them and put in oversized rings. This, of course, could not be carried on indefinitely on account of cutting away the metal. Today the worn places are filled up by electric welding and machined out so that the life of a steel piston is almost infinite. A cast-iron piston cannot be thus welded.

At times cracks develop in cylinder walls, especially in the vicinity of the exhaust ports, and formerly would necessitate the scrapping of the cylinder. Today these cracks are welded and seldom open up again; in fact, discarded cylinders have been reclaimed by this process to such an extent in one plant that four extra cylinders which were on order have been canceled. It would seem, therefore, that with the proper application of electric welding a gas engine that is built of steel should never wear out and would be replaced only as a matter of obsolescence.

The Deisel unit in this plant is a 1,500-kw. 4-cylinder two-stroke cycle engine generator outfit. The cylinders are 26 in. in diameter and the engine is built in sections so that it can be supplied as a 4-, 6- or 8-cylinder engine, and all of the like parts for each cylinder are interchangeable. The pistons are cast steel, while the cylinder is cast iron. The scavenging air inlet valve is in the center of the cylinder head, which has the inherent advantages of cleaning out absolutely all the burnt gases so that the compression stroke has a full supply of fresh air to compress each revolution.

*Extract of paper read before the sixteenth annual convention of the Association of Iron and Steel Electrical Engineers, Cleveland, Ohio, Sept. 11, 1922.

The Southern Power Co., of Charlotte, N. C., furnishing 300,000 hp. daily to industries in the two Carolinas, including 300 textile mills, will be forced to suspend operation for one day each week unless it receives more coal. Company officials said that they regarded the outlook for the next few weeks as extremely unfavorable, unless the rail strike should end, making available additional cars for coal carrying.

Fifty-Year Limit on Muscle Shoals Lease Again Proposed

As his solution of the Muscle Shoals problem, Representative Hull, of Iowa, introduced in the House on Wednesday, Sept. 20, a resolution authorizing the Secretary of War to sell to the Alabama Power Co. the government-owned Gorgas steam plant, substation and transmission line; to complete at government expense Dams Nos. 2 and 3 on the Tennessee River; to lease these dams for a period not exceeding 50 years, and to lease for not more than 50 years Nitrate Plants Nos. 1 and 2, and Waco quarry, near Muscle Shoals, either separately or completely, at $1 per year for each plant.

Representative Hull's plan differs from the Ford proposal in that he would have the government "lease" the nitrate plants for a negligible sum, instead of selling them outright. The Gorgas steam plant would not be included in the lease, and furthermore, Representative Hull proposes that the lease of the Muscle Shoals properties be for not more than 50 years, while Ford has insisted on a lease of 100 years' duration. Specifically, Representative Hull's proposal is as follows:

1. The Secretary of War is authorized to sell for not less than $3,000,000 to the Alabama Power Co. the government-owned steam plant and substation at Gorgas, Ala., the transmission line from Gorgas to Sheffield, Ala., and the substation at Sheffield.

2. If the Secretary of War is unable to obtain what he considers an adequate price for these properties, he is to purchase at his own price the land and rights-of-way on which they are located (which land is now owned by the Alabama Power Co.). Failing to purchase the land and rights-of-way at a satisfactory price, the Secretary of War is authorized to condemn the property for government use, under a law of Aug. 1, 1888.

3. The Secretary of War is authorized to purchase or condemn for government use all property and flowage rights concerning Dam No. 3, belonging to the Alabama Power Co., at a price not to exceed $100,000.

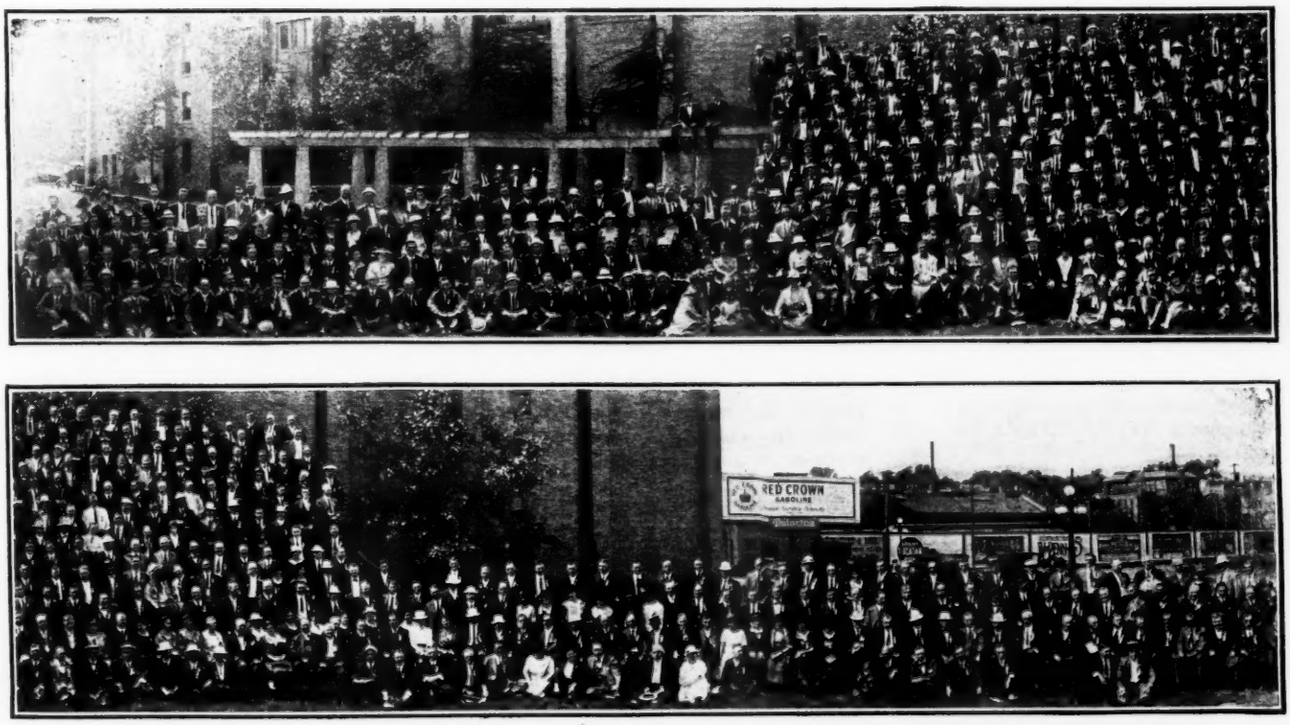
4. The Secretary of War is authorized to complete Dams Nos. 2 and 3 on the Tennessee River at government expense, or to contract for their completion, and to lease these dams for not more than 50 years at a rental not less than 4 per cent of the cost of finishing Dam No. 2 and of constructing Dam No. 3, including, in the case of Dam No. 3, the cost of the site and the flowage rights. The leases are to begin at such time as the Secretary of War may fix, the lessee being obliged to keep the dams and power houses in repair during the life of the lease.

5. The Secretary of War is authorized to lease for not more than 50 years the nitrate plants and Waco quarry, at one dollar a year for each plant, upon condition that the plants be operated to present capacity for the production of fertilizer for sale in this country, at a price not exceeding 8 per cent profit, and upon further condition that the leased property is to be kept in condition to produce to its present capacity nitrates and other components of munitions. It is specified that the nitrate plants, together with their personnel, are to be turned over to the United States in case of national emergency.

6. The Secretary of War may lease the dams and nitrate plants either to different persons or to the same person, and the lease of the plants may be made to expire at the same time as the lease of the dams.

This resolution was introduced by Representative Hull with the expressed belief that it would solve all phases of the problem. As action during the present session of Congress is not expected, the resolution will not be pressed until the opening of the next session, in December.

A new design in impulse turbine wheels, now being experimented with by the I. P. Morris Co. and its associate, the Pelton Water Wheel Co., is said to differ radically from anything now on the market. Successful experiments have been conducted at the Philadelphia plant of the Wm. Cramp & Sons Ship and Engine Building Co. Small wheels of the new design, embodying a flow normal to the runner plane instead of tangential, as in common practice, have shown higher efficiencies than usual, over a wide range of heads, including those in the neighborhood of 800 to 1,000 ft., where the relative merits of reaction and impulse turbines are frequently in dispute.



THE FORTIETH ANNUAL CONVENTION OF THE N. A. S. E., HELD AT DES MOINES, IOWA, SEPT. 11-15
(The convention was described in the Sept. 19 issue; the picture did not arrive in time for publication.)

News in the Field of Power

Indiana N.A.S.E. Favors A.S.M.E. Boiler Code as Standard

In view of the movement throughout the United States toward a uniform boiler law, and also in view of the fact that the A.S.M.E. Boiler Code is now in use in several states, the Anderson Association No. 16 of the National Association of Stationary Engineers, at Anderson, Ind., has adopted a resolution recommending that no changes in the present state boiler laws be made except in conformity with the A.S.M.E. Code. Copies of this resolution were sent to the governor, to the chief boiler inspector of the state, and to the dean of Purdue University.

This action on the part of the Indiana N.A.S.E. is in line with the present tendency toward universal adoption of the Code, for the A.S.M.E. reports that in seventeen states and eleven cities the Code has been either adopted or made operative through an enabling act.

To Settle St. Croix River Power Dispute

The Federal Power Commission has ordered hearings to settle the controversy over the proposed power project on the St. Croix River between Minnesota and Wisconsin. There are three applications for permits for the same site before the Commission: one by the Northern States Power Co., of Minneapolis, another by the City of St. Paul, and a third by the association of Markham, Kelsey & Draur, of St. Paul. St. Paul is interested in this site because it anticipates losing out in a similar controversy with Minneapolis over the federal high dam in the Mississippi River, described in *Power* for Sept. 5. St. Paul expects the Northern States Power Co. to win the right to develop the federal high dam, and therefore wishes to take over the flowage rights of that company on the St. Croix River.

Since the proposed St. Croix development would lie partly in Minnesota and partly in Wisconsin, the City of St. Paul has been asked to submit, at the hearings, such evidence as it may have of its authority to make a power development partly outside its own state.

New Lignite Fuel Produced

The Bureau of Mines has produced a lignite fuel in the course of its North Dakota experiments, at a cost comparable with that of the domestic sizes of anthracite in Pennsylvania. The reduction of the lignite ore was accomplished in a new type of shaft furnace, built after careful preliminary study. The results show a greater efficiency than had been anticipated, with costs low enough to demonstrate conclusively the practicability of establishing commercial plants. It is understood that North Dakota officials have plans under way which insure manufacture on a commercial scale. No small portion of the credit for the successful outcome of the experiments is given by the Bureau of Mines to Dean E. E. Babcock, of the University of North Dakota.

Transportation the Key to Coal Situation

That the present bituminous coal problem is purely one of transportation, the mines having ample capacity to meet the situation, even to the point of surplus, was agreed at the conference on the situation on Sept. 16 at the Department of Commerce. It was believed that coal prices could be greatly ameliorated if sufficient cars could be obtained, and if in the meantime consumers would purchase only for their immediate needs.

Secretary Hoover, in opening the conference, stated that the government welcomed the co-operation of the commercial and industrial community in solving the situation. It was most desirable, he said, that readjustments in prices and distribution should take place by the natural means of increased supply and the holding down of consumption pending such increase.

"In every situation such as this," the Secretary said, "there are social considerations which absolutely override the economic. The government cannot permit the distribution of coal this winter on a highest-bidder basis. That condition during the present emergency is an impossible social conception."

The conference voted to organize voluntary campaigns for three major purposes:

1. To induce manufacturers, utility corporations, and buyers generally not to purchase coal beyond their day-to-day needs until the flow of coal becomes more normal.

2. To persuade holders of coal contracts not to call for delivery on those contracts past their day-to-day needs. It was considered that about one-half of the coal in the country is under contract at normal prices and that a relaxation in the demand for this coal to the minimum daily requirements would allow an increase in supply to the general public.

3. To expedite the movement of coal in every possible way.

The conference was attended by officials of the United States Chamber of Commerce, the American Railway Association, the National Association of Manufacturers, the National Association of Purchasing Agents, and the Public Utilities Associations, and by the Secretary of Commerce, H. Foster Bain, of the Department of the Interior, and C. B. Aitchison, of the Interstate Commerce Commission.

How Powdered Coal Will Be Handled at Cahokia Plant

Some further details regarding the equipment to be used in handling pulverized coal at the new Cahokia station of the Union Electric Light and Fuel Co., St. Louis, Mo., have been announced. Among these the methods of weighing the fuel and conveying it from the pulverizers to the boilers are of interest.

Below the floor level of the pulverizing room will be placed a series of five blowing tanks, to serve an equal number of twin pulverizing units. Each tank will rest on platform scales, whose dial will indicate to the operator in the pulverizing room the amount of fuel in the tank. The coal will feed into these tanks by gravity from bins in the pulverizing room. Each charge will be automatically weighed and then elevated by compressed air to a height of about 75 ft. through 4-in. pipes. By means of a simple system of switching valves and parallel distributing mains, cross-connected, any blowing unit can discharge into any one of eight inclosed storage hoppers in the boiler house. These hoppers serve four pairs of boilers of 1,780 hp. each, comprising the first group of boiler units, whose fuel requirement is estimated at 1,000 tons in 16 hours. Quigley Fuel Systems, Inc., of New York City, has been awarded the contract for the coal-handling equipment.

Recent Water-Power Licenses and Permits

The Federal Power Commission has taken final action upon the grant of licenses in the following cases:

The Caddo River Power and Irrigation Co., of Little Rock, Ark., has been granted a license for fifty years to develop a power project on the Ouachita River, partly on government land within the Arkansas National Forest.

The Clarion River Power Co., of Foxburg, Pa., has been granted a license for fifty years for a power project on the Clarion River in the county of that name.

Four applications for preliminary permits have been granted by the Commission:

The application of the Saw Tooth Power Co., of Wilmington, Del., for a preliminary permit for power projects on Pass, Smith and other creeks, twenty-six in all, in Kougarck recording precinct, Alaska, has been granted for thirty months.

The California-Oregon Power Co., of San Francisco, has been granted a permit for two years for a power project on the Klamath River in Klamath County, Ore.. involving one or more dams. The permit is granted

with the understanding that investigations are being made of the so-called Klamath-Shasta irrigation district, and that the formation of such district and the diversion of water from the Klamath River might make a license for the power project impracticable or undesirable.

James H. Mays, of Salt Lake City, Utah, and Henry L. Gandy, of Rapid City, S. D., have been granted a preliminary permit for two years for a power project on Huntington Creek, Emery County, Utah.

The application for a preliminary permit of the Willow Creek Mines, a corporation of Seattle, Wash., for a power project on Craigie Creek, in Knik recording precinct, Alaska, has been granted for thirty months.

The Federal Power Commission has reaffirmed, after investigation, its previous decision that the proposed power development of the Grafton-Caledonia Power Co., of New Hampshire, on the Connecticut River in New Hampshire and Vermont, does not affect interstate commerce inasmuch as the river at this point is not a navigable stream.

The declaration of intention by Morrison & McCall, of St. Louis, Mo., for dams across Eleven Point and Spring Rivers in Randolph and Lawrence Counties, Ark., was declared by the Commission to affect interstate commerce and therefore to be within the jurisdiction of the Commission.

New Steam Plant in Iowa

The United Light and Railway Co., of Davenport, Iowa, has started construction work on a new plant for Fort Dodge, Iowa. At present a dam 6 ft. high is being built across the Des Moines River to insure an ample supply of water for the plant. Water-tube boilers, each containing 5,000 sq.ft. of surface, will be equipped with underfeed stokers running the entire length of the setting, with plenty of active grate area for burning a sufficient quantity of Iowa coal. The boilers will operate at 235 lb. and 150 deg. superheat. Coal and ash-handling equipment, superheaters and economizers are to be installed, and the present section of the plant will be equipped for induced draft. The initial installation will consist of a 2,000-kw. turbo-generator. Within a year a 3,000-kw. unit will be added, and provision is made for a 5,000-kw. turbine to follow as soon as needed.

Seattle and Tacoma To Exchange Electric Power

The cities of Seattle and Tacoma, Wash., have completed arrangements for the exchange of hydro-electric power in case of high demand or emergency conditions in the generating system of either city. Although somewhat elaborate in design, the scheme of connections, designed by Westinghouse engineers, is quite simple in operation.

Power is transmitted in each city at about 50,000 volts. A 15,000-kva. three-phase water-cooled transformer, having approximately a one-to-one ratio, will be used to tie the two systems together. A number of taps on one side of the transformer will make it possible to pass power, in any quantity up to 15,000 kva., from either system into the other. The entire range in voltage will be controlled by two push buttons, one to raise and the other to lower the voltage.

In anticipation of this arrangement, whereby power may be exchanged over a jointly owned municipal line, the two cities recently refused the offer of the Puget Sound Power and Light Co. to furnish them with a system of interconnection, in spite of the saving of 25 per cent promised by that company.

New Publications

Steam Engine Principles and Practice. By Terrell Croft. Published by McGraw-Hill Book Co., Inc., New York City. Cloth; 6x9 in.; 495 pages; 547 illustrations. Price, $3.50.

The author has the happy faculty of being able to explain in very simple elementary terms the principles of mechanics, etc. In this volume on the construction and operation of steam engines he has been able to outline most of the necessary steam-engine principles in a way that any engineer can understand. There is a complete avoidance of mathematics other than the simplest of arithmetical processes. The portion devoted to engine adjustment is not on as high a plane of excellence as other parts of the book, but even here there are many helpful suggestions. The volume covers the field of steam engineering in a manner somewhat different from other books of recent years and should meet with a ready approval from operating engineers.

The 20th Century Guide for Diesel Operators. By Rosbloom and Sawley. Published by Western Technical Book Co., Inc., Seattle, Wash. Cloth; 6x9 in.; 606 pages; numerous illustrations and tables. Price, $15.

One of the essential features that largely determine the worth of a technical book to the engineer is the matter of arrangement of the material. Few books, no matter how much valuable material contained between their covers, meet with general approval unless they have been subjected, prior to printing, to vigorous editing. The volume under discussion suffers in this respect. The material, of which much is of real worth, has been loosely and illogically put together. The authors have been so careless as to include repetition of statements, etc. One table, that of Baumé gravity reading, appears on five different pages.

In an attempt to simplify thermodynamics, the authors have made some inexcusable errors, as in speaking of molecules, the statement is made that such particles are so small that they can scarcely be seen with a high-powered microscope. Another very serious and unexcusable error is the omission of the meanings of the various symbols appearing in many equations. Since many of the formulas are empirical, the engineer, even though he is fairly familiar with formulas applying to mechanics, is at a loss to interpret the authors' meaning. The editing of the chapter on Theory is extremely poor, and this portion loses ninety per cent of its value.

The authors have in Chapter VI given a set of questions and answers on Diesel engines which are of practical value. The chapter on the operation of Diesel-electric marine units is likewise good, although the material is made up in the main of shop instructions issued by the several electrical companies. The portion of the work devoted to discussion of the many Diesel engines is apparently derived from statements made by the individual builders, for there are many contradictory statements. Much of this material has appeared in various technical publications and credit is not always given.

The volume contains a considerable amount of really valuable data, but the reader must be sufficiently acquainted with the subject of oil engines to separate the wheat from the chaff.

Coming Conventions

American Welding Society, 29 West 39th St., New York City. Fall meeting at Chicago, Ill., Oct. 2-5.
Society of Industrial Engineers, 29 West 39th St., New York City. National convention, New York City, Oct. 18-20.
Society of Naval Architects and Marine Engineers, 29 West 39th St., New York City. Annual meeting at New York City, Nov. 8-9.
American Society of Mechanical Engineers, 29 West 39th St., New York City. Annual meeting at New York City, Dec. 7-13.
National Exposition of Power and Mechanical Engineering, Grand Central Palace, New York City, Dec. 7-13.

Obituary

H. D. Crane, head of the M. H. Crane Estate, Cincinnati, Ohio, died on the morning of Sept. 15. Mr. Crane was a past-president of the old Master Steam Fitters' Association, and of the American Society of Heating & Ventilating Engineers. He was a graduate of Massachusetts Institute of Technology, was the only Cincinnati member of the Power Piping Association, and for more than forty years was identified with the power and heating industry.

Business Items

The Griscom-Russell Co., New York City, has bought the American rights for a new type of deaerating apparatus from the Contraflo Condenser & Kinetic Air Pump Co., Ltd., England.

Ophuls & Hill, Inc., 112-14 West 42 St., New York City, consulting engineers, have issued a pamphlet entitled "Five Years of Progress," illustrating a

number of refrigerating plants installed and equipped by them.

The Norwalk Iron Works Co. has announced a merger with the Automatic Carbonic Machine Co., of Peoria, Ill. The equipment of the latter company is being moved to the South Norwalk plant of the former.

Elliott Company, Pittsburgh, Pa., (sales offices and factory at Jeannette, Pa.), has opened a new district sales office in Atlanta, Ga., at 305 Haas-Howell Bldg., under the management of H. A. Hoffmann, formerly in the company's Philadelphia office.

The London Steam Turbine Co., Troy, N. Y., has appointed I. S. Forde as general sales manager. Mr. Forde is severing a twenty-year connection with the Westinghouse company. For the last seven years he has been general sales manager of the small turbine department at Pittsburgh.

C. J. Tagliabue Manufacturing Co., Cleveland, Ohio, has announced the return of A. R. Anderson, sales engineer, from an eighteen months' trip to England and the Continent in the interests of the Tagliabue company. Mr. Anderson will resume his duties in the Akron district.

The Westinghouse Electric & Manufacturing Co. has become agent for the De Laval transformer oil purifiers and dehydrators, centrifugal apparatus for the removal of sludge from lubricating oil and for the dehydration and purification of transformer and other insulating oils.

The Fuller-Lehigh Co., Fullerton, Pa., is furnishing equipment to burn pulverized bone coal in the plant of the United States Coal and Coke Co., Gary, W. Va. Each 800-hp. boiler will be equipped with five vertical burners, taking the powdered coal from 3-in. screw feeders.

The H. K. Ferguson Co. has announced the election of Joseph S. Ruble as vice-president in charge of all construction. For the last nine years Mr. Ruble was vice-president of the Austin Co. He is a member of the A.S.M.E. and has had nineteen years of construction engineering experience since graduating from Penn State College.

The A. M. Byers Co., Pittsburgh, Pa., has prepared a three-reel motion-picture film and a set of slides illustrating the manufacture of wrought-iron pipe from the smelting of the ore to the final inspection of the finished product. The film and slides are for the use of colleges, societies, etc., and will be loaned to them without cost.

F. J. Low Co., Inc., has been recently organized as an advertising agency, with offices at 15 West 44th St., New York City. F. J. Low is well known in the technical advertising field, having been advertising manager of H. W. Johns-Manville Co., and having been associated with the advertising of the Chicago Fuse Manufacturing Co., the American Steam Gauge and Valve Manufacturing Co., the Schaeffer & Budenberg Manufacturing Co., and others.

Trade Catalogs

Pulverizers—The Jeffrey Manufacturing Co., Columbus, Ohio. Catalog No. 368, showing the design, operation and application of the Jeffrey swing hammer pulverizer, used for pulverizing asbestos, bones, coal, coke, limestone, etc.

Relays—General Electric Co., Schenectady, N. Y. Bulletin No. 47606, twenty-eight pages, describing the company's line of relays and their operation and general application. The table of application of standard relays in the back of the bulletin gives the type of relay best suited to each of a variety of uses, illustrated throughout the booklet by a number of wiring diagrams.

Bearing Metals—A. W. Cadman Manufacturing Co., Pittsburgh, Pa. Engineering bulletins M-1 and M-2, containing much information on the application of the principles of metallography to the selection of bearing alloys. An attempt is made to give the user of bearing metals a clear understanding of what actually takes place in a bearing under various normal and abnormal conditions.

Steam Pumps—M. T. Davidson Co., 154 Nassau St., New York City. Catalog A, covering the Davidson line of steam pumps for stationary service, and giving instructions for care and operation, and useful tables of circular areas, metric conversions, cylindrical volumes in cubic feet and in U. S. gallons for one foot of length, friction loss in pipes in pounds per square inch, and water pressure conversion from feet head to pressure per square inch.

Heating and Power Plant Specialties—McAlear Manufacturing Co., 1901-7 Southwestern Ave., Chicago, Ill. Catalog No. 27, 128 pages, describing the company's line of specialties for steam heating and power plants, including an individual temperature-control valve for steam radiators, balanced float valves, vacuum back-pressure valves, ball float steam traps, radiator traps, vacuum and vapor heating systems, oil-refining and waterworks plants, plumbing systems, etc.

Pneumatic Collecting and Conveying Systems—B. F. Sturtevant Co., Hyde Park, Boston, Mass. Catalog No. 291, covering very completely the application of Sturtevant fans to air washer systems, the removal of dust from grinding, buffing and polishing wheels, the conveying of pulverized coal, and the removal of fumes and gases. Seventeen pages of useful tables are given—how to find the size of fan, the suction, volume, r.p.m., and horsepower for any system, the cubic feet of air handled per minute, the size of pipe and ducts used, etc.

Variable Speed Transmission—Reeves Pulley Co., Columbus, Ind. A so-called "Engineers' Manual" of 36 pages, containing information on the installation and care of "The Reeves" variable speed transmission. This transmission was described in connection with the Reeves Automatic Stoker Control in *Power* for July 25, 1922, on page 133. Tables of pulley speeds, horsepower transmitted and prices are given at the back of the booklet.

Flow Meter—H. S. B. W.-Cochrane Corp., Philadelphia, Pa. Catalog No. 1087, describing in great detail the principles upon which the Cochrane Flow Meter operates. This recording meter may be used for either steam or water in pipes. Tables of standard orifice metering elements for both water and steam are given.

Ash Conveyors—Conveyors Corp. of America, 326 West Madison St., Chicago, Ill. "Modern Methods of Ash Disposal," containing 160 pages, is one of the most complete and valuable catalogs ever published on the subject. The various methods and all types of conveying equipment employing horizontal and vertical movement are compared, including the steam-jet conveyor, of which this company is the originator. Mechanical details of the conveyor are featured, typical installations illustrated and some mention made of "American" cast-iron storage tanks. The catalog also contains useful engineering data, the feature being tabulated analyses of the various coals of the United States.

Fuel Prices

BITUMINOUS COAL

The following table shows the trend of the spot steam market in various coals (mine run bases, f.o.b. mines):

Coal	Market Quoting	Sept. 11, 1922	Sept. 18, 1922
Pool 1,	New York	.....	$5.00–5.75
Smokeless,	Columbus	$5.00–6.50	5.50–6.00
Clearfield,	Boston	4.50–5.50	4.00–4.75
Somerset,	Boston	4.50–5.75	4.50–5.25
Kanawha,	Columbus	5.75–6.25	5.25–5.75
Hocking,	Columbus	5.25–6.00	4.75–5.50
Pittsburgh No. 8	Cleveland	5.00–5.25	4.50–4.75
Franklin, Ill.,	Chicago	4.50–5.00	4.50–5.00
Central, Ill.,	Chicago	4.25–4.75	4.35–4.75
Ind. 4th Vein,	Chicago	4.65–5.00	4.65–5.00
West Ky.,	Louisville	4.00–4.50	4.00–4.50
Big Seam,	Birmingham	2.60–4.00	2.60
S. E. Ky.,	Louisville	5.25–6.00	5.25–6.00

FUEL OIL

New York—Sept. 21, Port Arthur light oil, 22@25 deg. Baumé, 5c. per gal.; 30@35 deg., 5½c. per gal., f.o.b. Bayonne, N. J.

Chicago—Sept. 16, for 24@26 deg. Baumé, $1.50 per bbl.; 32@36 deg., 3½c. per gal. in tank cars, f.o.b. Oklahoma refinery, or freight adjusted.

Pittsburgh—Sept. 12, f.o.b. refinery, Pennsylvania, 36@40 deg., 6¼c.; Kentucky fuel oil, 26@30 deg., 4¼c. per gal.; Gas oil, 32@34 deg., 2¾c. per gal.; 36@38 deg., 3c.; 38@40 deg., 3¼c.; Western, 24@30 deg., $1.30 per bbl.

Philadelphia—Sept. 18, 26@28 deg. Baumé, Oklahoma, $1.25@$1.30 per bbl.; 30@34 deg., Oklahoma (group 3), 3¼@3½c. per gal.; 16@20 deg. Seaboard, $1.50@$1.60 per bbl.

Cincinnati—Aug. 21, for 26@28 deg. Baumé, 5¼c.; Diesel, 28@30 deg. 5½c. per gal.; distillate 38@40 deg., 6c.

Cleveland—Aug. 21, 26@28 deg. Baumé, 4¼c. per gal.

New Plant Construction

PROPOSED WORK

Calif., Crockett—The School Dist. plans election to vote $250,000 bonds for new school. Architect not selected.

Calif., Grenada—The Grenada Irrigation Dist., received bids for rebuilding pumping plants from L. Youdall, Comm. Savings Bldg., Stockton, $5,255, P. Butte, 534 Folsom St., San Francisco, $6,527; structures for 24 mi. of canals, including checks, 74 turnouts, etc., D. M. Reid, $7,369, M. Steuart, $8,985; ditches, 14 mi. new canal, and deepening 7 mi. present canals, etc., G. Milne, Fort Jones, new ditches $6,327, enlargements $12,344; reconstructing dam and concrete lining of pumping plant sump and dividing canal, M. Steuart, $14,961, L. Youdall, $17,440. Noted Apr. 1.

Calif., Lakeport—The city received bids for engines in connection with proposed waterworks and sewer equipment system, from the Henry Lund Co., Marine Bldg., San Francisco, as follows: one 25 hp. oil burning, belt driven, friction pulley engine $2,587; one 10 hp. $1,264.

Calif., Merced—The Merced Irrigation Dist. Bd. Directors, will receive bids until Oct. 3 for furnishing 2 vertical type booster plants to handle 30 sec.ft. of water against a 24 ft. head.

Calif., Oakland—The Chevrolet Motor Co., 3044 West Grand Blvd., Detroit, plans to build a 2 story, 146 x 684 ft. plant for the manufacture of automobile bodies, on Hillside Ave. Estimated cost $600,000. A. Kahn, 1000 Marquette Bldg., Detroit, Archt.

Conn., Bridgeport—Bd. Educ. plans to build a 3 story high school on Boston and Central Aves. Estimated cost $900,000. Architect not selected.

Del., Claymont—The Bd. Educ. is having plans prepared for a 2 story, 80 x280 ft. high school, including steam heating system. Estimated cost $275,000. Coffin & Coffin, 522 Fifth Ave., Archts. and Engrs. Noted Aug. 2.

D. C., Wash.—The Christian Bros., Armendale, Md., are having plans prepared for the construction of college buildings, here. Estimated cost $500,000. Murphy & Ohmsted, 1413 H St., N.W., Archts.

D. C. Wash.—J. M. Donn, Archt., 1147 Connecticut Ave., N.W, is preparing plans for an 8 story, 112 x 112 ft. apartment building. Estimated cost $1,000,000. Owner's name withheld.

D. C., Wash.—The Powhatan Hotel Co., 18th St. and Pennsylvania Ave., NW., plans to build a 10 story, 180 room addition to hotel. Estimated cost $500,000. Architect not selected.

Fla., Brooksville—The Hernando County Dairy Co. is in the market for ice making and refrigerating plant machinery for proposed $55,000 dairy plant.

Fla., Haines City—The city council, J. R. Yale, Clk., will receive bids until Oct. 3 for waterworks system, consisting of pumping station, and equipment, 100,000 gal. elevated tank, clear water collecting well and about 4 mi. 4 to 10 in. c.i. pipe, with specials, valves and hydrants also sewer system consisting of about 1.7 mi. 8, 10 and 15 in. vitrified pipe with manholes, flush tanks, and appurtenances settling tank and tile under-drain system.

Fla., Orlando—M. Overstreet, J. L. Giles, et al., are having plans prepared for a 100 room hotel. Estimated cost $300,000. E. Krug, c/o M. Overstreet, Archt.

Ga., Rome—Battey Machine Co., West 2nd Ave., is in the market for one 10 x 12 Ingersoll-Rand belt driven compressor, 100 lb. pressure and one 50 hp. 3 phase, 60 cycle, 220 volt motor, to drive compressor.

Ill., Chicago — The B.P.O.E. Building Comn., 50 East 42nd St., New York, is having plans prepared for a memorial club house, including steam heating system, on Lakeview Ave. Estimated cost $3,000,000. E. Swartout, 18 West 34th St., New York, Archt. and Engr.

Ill., Oak Park—The Atlas Educational Film Co., 1111 South Blvd., is in the market for 50 kw. motor generator, 125 volts, motor must be 200 volts, 3 phase, 60 cycle, slip ring type.

Ia., Des Moines—The Equitable Life Insurance Co. of Iowa, Bankers Trust Bldg., will soon receive bids on the superstructure of an 18 story, 132 x 133 ft. office building, including steam heating system, on 6th and Locust Sts. Estimated cost $2,000,000. Proudfoot, Bird & Rawson, 810 Hubbell Bldg., Archts. Contract awarded for foundation, to the A. H. Neumann Co., 519 Hubbell Bldg., $109,800.

Kan., Atchison—The Blair Milling, Co., 300 South 4th St., will receive bids about Sept. 28 for a 6 story, 36 x 83 ft. flour mill, storage capacity 50,000 bu. Horner & Wyatt, 306 McMillian Bldg., Kansas City, Mo., Archts.

Md., Baltimore—Bd. Educ., Dr. H. S. West, Supt., 1310 Madison Ave., is having plans prepared which will be ready about Oct. 15 for a 4 story, irregular school building, including steam heating plant, on Nevada and First Sts. Estimated cost $300,000. B. Frank, 328 North Charles St., Archt. J. Posey, 11 Pleasant St., Engr.

Mass., Boston—Coleman & Gilbert, 331 Huntington Ave., are having plans prepared for a store and apartment building on Huntington Ave. and Gainsborough St. Estimated cost $400,000 to $500,000. Architect not announced.

Mass., Waverly—The State Dept. of Mental Diseases, W. A. Merrill, Bus. Agt., State House, Boston, received bids for a 75 x 78 ft. power house for the Massachusetts School for Feeble Minded, here, from T. J. McMahon, Framingham, $34,836, J. J. Ferindiville, South Framingham, $36,041, J. S. Griffin Co., 15 Exchange St., Boston, $36,644. Noted Sept. 19.

Mich., Detroit—The Bd. Educ., 1354 Broadway Ave., will receive bids until Sept. 28, for a 2 story, 58 x 182 ft. and 67 x 181 ft. school additions, including steam heating, boilers and equipment, Plenum system and mechanical ventilators, on Duboise and Waterloo Sts. Estimated cost $250,000. Malcolmson, Higginbotham & Palmer, 405 Moffat Bldg., Archts.

Mich., Detroit—Whitney-Hollinger Co., 408 Dime Bank Bldg., plans to build a 4 story, 50 x 150 ft. manufacturing building, including steam heating plant, on Inner Belt Railroad. Estimated cost $1,000,000. Architect's name withheld.

Mich., Detroit—Wormer & Moore, 514 Griswold St., are having plans prepared for an 8 story, 60 x 120 ft. office building, including steam heating, boiler and accessories, on Park & Montcalm Aves. Estimated cost $250,000. Bonnah & Chaffe, 528 Farwell Bldg., Archts.

Mo., Kansas City—The Liberty Memorial Assoc., is having plans prepared for a memorial building on Union Station Plaza. Estimated cost $2,000,000. H. Van Buren Magonigle, 101 Park Ave., New York, Archt. Noted July 26, 1921.

Mo., North Kansas City—The Kansas Flour Mills Co., Postal Telegraph Bldg., Kansas City, will soon award the contract for an 8 story, 64 x 204 ft. flour mill, 300,000 bu. capacity, including 14 tanks 20 in. dia. 90 ft. high. Burrel Engr. Co., 403 Arcade Bldg., Kansas City, Archts and Engrs.

N. J., Paterson—The Paterson General Hospital is having sketches prepared for a 4 story addition to hospital including steam heating system, on Market St. Estimated cost $400,000. Crow, Lewis & Wick, 200 5th Ave., New York, Archts. and Engrs.

N. J., West Orange—The Bd. Educ. will soon award the contract for a school. About $350,000. Guilbert & Bettelle, 548 Broad St., Newark, Archts. and Engrs.

N. Y., Arverne (Far Rockaway P. O.)—The Dept. Educ., 500 Park Ave., New York, plans to build a high school, including steam heating system, on Beach, 61 St. and Blvd., here. Estimated cost $1,260,000. C. B. J. Snyder, Flatbush Ave. and Concord St., Bklyn., Archt. and Engr.

N. Y., Brooklyn—The State Hospital Comn., Capitol, Albany, will soon receive bids for the construction of 4 buildings, two 36 x 404 ft. 4 wings, 44 x 74 ft. for North and South Chronic Hospital for Insane, 137 x 137 ft. kitchen and dining room building, 114 x 145 ft. power house, capacity 600 kw. 3 phase 60 cycle a.c., two 300 hp. and one 150 hp. engines, two 500 hp. boilers, 2 blower engines, pumps, etc., for the Brooklyn State Hospital, Creedmore Div. Total cost $2,000,000. L. F. Pilcher, State Archt., Albany.

N. Y., Chelsea—The Treasury Dept., Super. Archt's. Office, Wash., D. C., will receive bids until Oct. 16 for the construction of a U. S. Veterans' Hospital, here, including mechanical equipment.

N. Y., East Aurora—The Bd. Trustees, D. N. Rumsey, Clk., will receive bids until Sept. 27 for the installation of one 12 in. x 12 in. vertical, triplex, single acting pump, one 60 hp., 3 phase, 25 cycle, 440 volt slip ring motor, foundations, wiring and pipe connections. Separate bids wanted on machinery and wiring.

N. Y., Geneva—The Lisk Mfg. Co., Canandaigua, plans the construction of an enameling plant on a 14 acre site, here. Estimated cost $1,000,000. Architect not announced. Prices wanted on machinery and equipment.

N. Y., Jamestown—Jamestown Worsted Mills Co., 335 Harrison St., is having plans prepared for the construction of a 4 story, 70 x 186 ft. factory (No. 16). Estimated cost $250,000. Lockwood, Greene & Co., 1556 Hanna Bldg., Cleveland, O., Archts.

N. Y., Long Island City—The Rerg Renovating Co., 252 Van Alst Ave., is in the market for a steam gas boiler, 10 to 15 hp.

N. Y., New York—The Dept. of Health, 505 Pearl St., will receive bids until Sept. 29 for furnishing labor and materials for the erection, completion and alterations, for a coal handling plant at the Riverside Hospital on North Brother Island, Boro. of Bronx.

N. Y., New York—W. Guzzardi, Belleclaire Hotel, Bway. and 77th St., is having plans prepared for a 10 story addition to hotel, including steam heating system, on West 77th St. Private plans.

N. Y., New York—The 33 West 60th St. Corp., c/o Rouse & Goldstone, Archts. and Engrs., 512 Fifth Ave., is having plans prepared for an 11 story, 100 x 109 ft. office building, including steam heating system, at 27 West 60th St. Estimated cost $500,000.

N. Y., Owego—The Bd. Educ., will soon receive bids for a 3 story, 150 x 200 ft. school, including a steam heating system. Estimated cost $275,000. Coffin & Coffin, 522 5th Ave., New York, Archts. and Engrs. Noted Apr. 4.

N. Y., Patchogue—The Bd. Educ. is having plans prepared for a high school. Estimated cost $500,000. Tooker & Marsh, 101 Park Ave., New York, Archts.

N. Y., Spring Valley—The Bd. Educ., is having plans prepared for a high school, including steam heating system. Estimated cost $250,000. E. Sibley, Palisade, N. J., Archt. and Engr.

N. Y., Tupper Lake — The Bureau of Yards & Docks, Navy Dept., Wash., D. C., will receive bids until Oct. 11 for the construction of a U. S. Veterans Hospital, here, consisting of 8 buildings. Estimated cost $1,000,000. Spec. 4710. Noted Sept. 19.

Ohio, Massilon—Bd. Educ. plans to build a 2 story junior high school, including steam heating plant. Estimated cost $250,000. Albrecht, Wilhelm & Kelly, 1836 Euclid Ave., Cleveland, Archts.

Pa., Altoona — The Bd. Educ., W. N. Decker, Secy., 6th Ave. and 15th St., will receive bids until Oct. 16 for a 3 story, 160 x 200 ft. junior high school, including auxiliary heating system, on 6th and 7th Aves. Estimated cost $500,000. J. Millard, Hutchinson Bldg., Archt. W. D. Ittner, 911 Locust St., St. Louis, Mo., Assoc. Archt.

Pa., Forest City—The School Dist., E. E. Horton, Secy., is receiving bids for 1 Ideal 3-A-10 or 1-S 36-F-15 water tube boiler with asbestos covering.

Pa., Phila.—J. J. Greenberg, c/o Nash Motor Co., 901 North Broad St., will soon receive bids for a 5 story, 75 x 160 ft. sales and service building on Broad and Thompson Sts. Estimated cost $250,000. P. S. Lyre, 1509 Arch St., Archt.

Pa., Phila.—Mastbaum Bros. & Fletcher, 15th and Chestnut Sts., plan to build a 12 story, 102 x 188 ft. office and store building on 21st and Market Sts. Estimated cost $1,000,000. Hoffman Henon Co., Finance Bldg., Archts.

S. C., Camden—The Herfuth Engine & Mchy. Co., is in the market for a 75 hp. oil engine.

S. C., Greenville—The Judson Mills Community Bldg., plans to build a 2 story, 175 x 300 ft. textile mill. Estimated cost $600,000. J. E. Sirrine Co., South Main St., Engrs.

Tenn., Memphis—Hanker & Cairns, Madison Ave. Bldg., will receive bids until Sept. 29 for the construction of a 4 story office and lodge room building on South Front St. and Monroe Ave. Estimated cost $500,000. Jones & Furbinger, Porter Bldg., Archts.

Tenn., Memphis—The Memphis Artesian Water Dept., Bd. Comrs., will receive bids until Oct. 6, for the construction of reservoir, substructures of a pumping station, iron removal plant and aerator, furnishing and installing c.i. pipe, valves, drains and appurtenant structures. Fuller & McClintock, 421 Produce Exchange Bldg., Kansas City, Mo., Engrs.

Tenn., Memphis—Tri-States Hotel Co. will soon award the contract for a 15 story, 350 room hotel, including steam heating and ventilating system, on North Main and Adams Sts. Estimated cost $1,000,000. Jones & Furbinger, Porter Bldg., Archts. Noted April 5, 1921.

Tex., Ft. Worth—The Methodist Hospital, Bd. Trustees, Judge W. E. Williams, Secy., is having plans prepared for a 5 story, 400-bed hospital. Estimated cost $1,000,000. Clarkson & Gaines, 1st Natl. Bank Bldg., Archts.

Tex., Tulia—The city plans an election Oct. 12, to vote $25,000 bonds for an electric light plant.

Wash., Kelso—The Long Bell Lumber Co., R. A. Long Bldg., Kansas City, Mo., is having plans prepared for the construction of school, church, hospital, Y.M.C.A., city hall and residences, also light and water plants, for industrial city near here. F. E. McIlvain, 1001 Orear Leslie Bldg., Kansas City, Mo., Archts.

Wash., Locke—The Locke Drainage District Comrs., are receiving bids for levee work, including pump, engine, etc. Estimated cost $45,000 to $50,000. Engineer not announced.

Wash., Omak—The city voted $13,500 bonds for pumping plant, including reservoir and extension of water mains.

Wash., Spokane—The city is having plans prepared and takes bids 1923 for waterworks improvements as follows: 20,000,000 gal. reservoir, estimated cost $140,000, pumping outfit, 1 unit of 1,000 hp. 50,000 gal. per day capacity, housing, 1 well 50 ft. dia. and 55 ft. deep, $65,000; foundation for pump in old plant, 300 hp. engine, $15,000; replacing wooden pipe by 10,000 ft. 6 in. c.i. pipe, $17,500. A. Lindsay, City Hall, Engr.

Wash., Spokane—The Spokane Valley Irrigation Dist. will vote on $500,000 bonds for irrigation project, including hydraulic turbine, 2 centrifugal pumps of 5 sec. ft. each. Estimated cost $500,000. R. K. Tiffany, Old National Bank Bldg., Engr.

Wis., Appleton—The city, E. L. Williams, Clk., plans to build two 4 story, 75 x 190 ft. junior high schools, including steam heating systems. Estimated cost $500,000. Architect not selected.

Wis., Marshfield—C. E. Blodgett is having plans prepared for a steam heating plant, including boiler, in building to be leased to the U. S. Post Office. Private plans.

Wis., Milwaukee—M. A. Weinreis, 246 Oregon St., is in the market for 2 belt driven air compressors, 250 to 300 cu.ft., 100 lb. working pressure.

Que., Hull—The Hull Electric Railway, G. G. Gale, Mgr., plans developments at Paygou Falls on the Gatineau River, to furnish 150,000 hp. electrical energy to Ottawa and district. This corrects report of Sept. 19.

Que., Montreal—The Dept. Pub. Works, H. A. Terreault, Dir., will soon receive bids for the construction of a 5 story city hall, to replace the one destroyed by fire. About $1,000,000. L. Parent, City Archt.

Que., Rimouski—The Lower St. Lawrence Power Co. is in the market for complete machinery and equipment for proposed power plant.

Australia, Victoria, Melbourne — The State Electricity Comn., R. Liddelow, Secy., will receive bids until Dec. 18 for coal handling plant for the Morwell Power Scheme. Spec. 282.

CONTRACTS AWARDED

Calif., Mare Island—The Bureau of Yards & Docks, Navy Dept., Wash., D. C., awarded the contract for circulating loop, for the central power plant here, to the Tibbitts Pacific Co., 16 California St., San Francisco, $104,960. Spec. 4684. Noted Aug. 8.

Calif., Turlock—The Turlock Irrigation Dist., awarded the contract for furnishing four 1,000 kva. electrical transformers, to the General Electric Co., Rialto Bldg., San Francisco, $13.950. Noted Aug 29.

Fla., Orlando—The city awarded the contracts for enlarging and renovating waterworks plant as follows: pumps, Morris Machine Wks., 41 Cortlandt St., New York, $4,785; condensers, D. H. Wheeler, New York, $11,560; super-heaters, Power Specialty Co., 111 Bway., New York, $4,100; stack, Rust Engr. Co., Atlanta, Ga., $3,360; filtration equipment, International Filter Co., 38 South Dearborn St., Chicago, $17,446; boilers, Springfield Boiler Co., 1901 East Capital Ave., $27,114.

Mich., Detroit—The Kroger Grocery & Baking Co., 817 Main St., Cincinnati, O., awarded the contract for a 2 and 3 story, 203 x 424 ft. bakery and warehouse, on Merritt Ave., to John Finn & Co., 7729 Plymouth Rd., $300,000. Steam heating plant will be installed.

Mich., Flint—Fisher Body Ohio Co., East 140 St. and Coit Rd., awarded the contract for the construction of a 2 story, 202 x 401 ft. factory for assembling automobile bodies, including steam heating plant, to the Realty Constr. Co. Estimated cost $500,000.

Minn., Minneapolis—J. Friedman, 1900 Emerson Ave. S., awarded the contract for a 13 story, 50 x 100 ft. apartment hotel with three 6 story wings, on Mt. Curve and Douglas Aves., to Fleisher Constr. Co., 1000 Bldrs. Exch. Estimated cost $1,500,000. Steam heating system will be installed.

Minn., Thief River Falls—The city, A. K. Akre, Clk., awarded the contract for waterworks improvements including 1,000,000 gal. filtration plant and motor house to C. M. Carlson, $19,100, filter and pump equipment to J. G. Robertson, 2542 University Ave., St. Paul, $15,170. Noted Sept. 5.

N. Y., Avoca—The Bd. Educ., awarded the contract for a 330 x 380 ft. high school, to L. Dennison, 162 North Main St., Hornell. About $350,000. Steam heating system will be installed.

N. Y., Buffalo—The Bd. Educ., 1401 Telephone Bldg., awarded the contract for school on Clinton St. to Tifft Constr. Co., Iroquois Bldg., $336,651, heating and ventilating to R. J. Morgan, 379 East Utica St., $61,645. Noted Sept. 5.

N. Y., Fulton—The Peters Chocolate Co., awarded the contract for a 40 x 80 ft. boiler house, including 8 x 8 x 140 ft. power tunnel and boiler and chimney foundations, to the Barto-Phillips Co., 52 Vanderbilt Ave., New York. Estimated cost $50,000.

N. Y., Hudson — The Holbrook Co., awarded the contract for 100 x 260 ft. manufacturing building, 20 x 30 ft. boiler house, including 100 hp. boiler with 100 ft. radial stack, 20 x 30 ft. service building and 25 x 50 ft. connecting passage, etc., to the Barto-Phillips Co., 52 Vanderbilt Ave., New York. Estimated cost $80,000.

N. Y., New York—The Bd. Educ. awarded the contract for P. S. 64, on Walton Ave. and East 171st St. to T. Dwyer, Bway and 216th St. $624,000.

N. Y., New York—The Empire Hotel, Columbus Ave. and 73rd St., awarded the contract for a 12 story, 115 x 130 ft. hotel, to the Empire Contracting Organization, Inc., 130 West 42nd St. About $750,000. Steam heating system will be installed.

N. Y., New York—F. F. French, 299 Madison Ave., will build a 14 story, 50 x 80 ft. apartment building on Park Ave. Estimated cost $750,000.

N. Y., New York—The Jatison Constr. Co., c/o Schwartz & Gross, Archts., 347 5th Ave., will build by day labor, a 9 story, 84 x 100 ft. apartment building at 146 West 55th St. Steam heating system will be installed.

N. Y., New York—M. Paterno, 200 West 72rd St., will build a 14 story apartment, including steam heating system, on Park Ave. and East 86th St. Estimated cost $1,500,000. Private plans. Work will be done by separate contracts under supervision of owner.

Ohio, Cleveland—The A. Claus Mfg. Co., A. H. Claus, Pres., 5701 Walworth Ave., awarded the contract for a 1 story, 80 x 450 and 80 x 240 ft. factory and warehouse on Brook Park Rd., to the H. G. Slatmyer & Son Constr. Co., 203 Lakeside Ave., N. W. Estimated cost $250,000.

Okla., Tulsa—The Bd. Educ., awarded the contract for a 4 story, 125 x 260 ft. central high school on 6th and Cincinnati Sts. to the Van Horn Constr. Co., Kansas City, Mo., refrigerating plant to the John Mansville Co., 622 Mayo Bldg. Estimated cost $1,000,000. Noted Aug. 29.

Pa., Erie—The Bd. Educ., awarded the contract for a 2 story, 200 x 304 ft. junior high school on 23rd and Cascade Sts. to H. J. Conrath, Ariel Bldg. Estimated cost $450,000.

Pa., Phila.—The Academy of Sacred Heart, 1819 Arch St., awarded the contract for a 3 story, 42 x 174 ft. academy, on Haverford and City Line Aves., to Doyle & Co., 1519 Sansom St. Estimated cost $500,000.

Pa., Phila.—T. B. Gibbs, c/o Carson & Carson, Archts., 1620 15th St., awarded the contract for a 10 story, 19 x 104 ft. office and sales building to Hughes-Foulkrod Co., Commonwealth Bldg. Estimated cost $575,000.

Pa., Phila.—A. M. Greenfield & Co., 15th and Chestnut Sts., awarded the contract for a 20 story, 79 x 138 ft. office building, to the F. W. Mark Constr. Co., Commercial Trust Bldg., $1,250,000. Noted Jan. 31.

Va., Winchester—The city awarded the contract for a 197 x 551 ft. memorial school with auditorium to seat 2,000, to J. L. Krouse, Greensboro, N. C., $1,000,000.

Wis., Hartford—The Kissel Motor Car Co., awarded the contract for structural steel for 40 x 80 ft. power house, to the Milwaukee Bridge Co., 1400 34th St., Milwaukee. Estimated total cost $40,000. Noted Aug. 29.

Wis., Milwaukee—Hotel Investors, Inc., 330 Caswell Blk., awarded the contract for a 3 story apartment hotel, consisting of 2 units, each 50 x 110 ft., on Cass St., to Brun Constr. Co., 387 Clinton St., Milwaukee. Estimated cost $250,000.

Wis., Park Falls—The Flambeau Paper Co., awarded the contract for dam, 70 ft. long, 18 ft. head, to F. Wells, c/o owner. Two tainter gates will be installed. Estimated cost $50,000. Noted Mar. 16.

Wis., Sheboygan—The city, J. Steimle, Clk., awarded the contract for furnishing and installing boiler and equipment at the city pumping station, to the Kidwell Boiler & Engine Co., 288 East Water St., Milwaukee. Estimated cost $25,000. Noted July 4.

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